EXHIBIT NN

UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF TEXAS
MARSHALL DIVISION

VIRTAMOVE, CORP., Plaintiff, v. INTERNATIONAL BUSINESS MACHINES CORP., Defendant.	Case No. 2:24-cv-00064-JRG-RSP

PLAINTIFF VIRTAMOVE, CORP.'S CORRECTED PRELIMINARY DISCLOSURE OF ASSERTED CLAIMS AND INFRINGEMENT CONTENTIONS

I. Patent Rule 3-1: Disclosure of Asserted Claims and Infringement Contentions

Pursuant to Patent Rule 3-1, Plaintiff VirtaMove, Corp. submits the following Preliminary Disclosure of Asserted Claims and Infringement Contentions. This disclosure is based on the information available to VirtaMove as of the date of this disclosure, and VirtaMove reserves the right to amend this disclosure to the full extent permitted, consistent with the Court's Rules and Orders.

A. Patent Rule 3-1(a): Asserted Claims

VirtaMove asserts that Defendant International Business Machines Corp. ("Defendant" or "IBM") infringes the following claims (collectively, "Asserted Claims"):

(1) U.S. Patent No. 7,519,814 ("the '814 patent"), claims 1, 2, 6, 9, and 10; and

(2) U.S. Patent No. 7,784,058 ("the '058 patent"), claims 1–4 and 18.

This Corrected Preliminary Disclosure of Asserted Claims and Infringement Contentions correctly reflects, consistent with the Complaint (IBM Dkt. 1) and the Amended Complaints (Consolidated Dkts. 37, 47), that the only independent claims that are asserted in this case are

independent claim 1 of the '814 patent and independent claim 1 of the '058 patent. Independent Claim 31 of the '814 patent is not, was not, and will not be asserted in this case. Otherwise, this Corrected Preliminary Disclosure of Asserted Claims and Infringement Contentions is identical to the previously served Preliminary Disclosure of Asserted Claims and Infringement Contentions.

B. Patent Rule 3-1(b): Accused Instrumentalities of which VirtaMove is aware

VirtaMove asserts that the Asserted Claims are infringed by the various instrumentalities used, made, sold, offered for sale, or imported into the United States by Defendant, including certain (a) IBM products and services using secure containerized applications, including without limitation IBM's Cloud Kubernetes Service (IKS), IBM Cloud Private (ICP), and IBM Hybrid Cloud mesh, and all versions and variations thereof since the issuance of the '814 patent; and (b) IBM products and services using user mode critical system elements as shared libraries, including without limitation IBM Cloud Kubernetes Service (IKS), IBM Cloud Private (ICP), and IBM Hybrid Cloud mesh, and all versions and variations thereof since the issuance of the '058 patent ("Accused Instrumentalities"). Defendant's Accused Instrumentalities of which VirtaMove is presently aware are described in more detail in the accompanying preliminary infringement contention charts.

VirtaMove reserves the right to accuse additional products from Defendant to the extent VirtaMove becomes aware of additional products during the discovery process. Unless otherwise stated, VirtaMove's assertions of infringement apply to all variations, versions, and applications of each of the Accused Instrumentalities, on information and belief, that different variations, versions, and applications of each of the Accused Instrumentalities are substantially the same for purposes of infringement of the Asserted Claims.

C. Patent Rule 3-1(c): Claim Charts

VirtaMove's analysis of Defendant's products is based upon limited information that is publicly available, and based on VirtaMove's own investigation prior to any discovery in these actions. Specifically, VirtaMove's analysis is based on certain limited resources that evidence certain products made, sold, used, or imported into the United States by Defendant.

VirtaMove reserves the right to amend or supplement these disclosures for any of the following reasons:

(1) Defendant and/or third parties provide evidence relating to the Accused Instrumentalities;

(2) VirtaMove's position on infringement of specific claims may depend on the claim constructions adopted by the Court, which has not yet occured; and

(3) VirtaMove's investigation and analysis of Defendant's Accused Instrumentalities is based upon public information and VirtaMove's own investigations. VirtaMove reserves the right to amend these contentions based upon discovery of non-public information that VirtaMove anticipates receiving during discovery.

Attached, and incorporated herein in their entirety, are charts identifying where each element of the Asserted Claims are found in the Accused Instrumentalities.

Unless otherwise indicated, the information provided that corresponds to each claim element is considered to indicate that each claim element is found within each of the different variations, versions, and applications of each of the respective Accused Instrumentalities described above.

D. Patent Rule 3-1(d): Literal Infringement / Doctrine of Equivalents

With respect to the patents at issue, each element of each Asserted Claim is considered to be literally present. VirtaMove also contends that each Asserted Claim is infringed or has been infringed under the doctrine of equivalents in Defendant's Accused Instrumentalities. VirtaMove

also contends that Defendant both directly and indirectly infringes the Asserted Claims. For example, the Accused Instrumentalities are provided by the Defendant to customers, who are actively encouraged and instructed (for example, through Defendant's online instructions on its website and instructions, manual, or user guides that are provided with the Accused Instrumentalities) by Defendant to use the Accused Instrumentalities in ways that directly infringe the Asserted Claims. Defendant therefore specifically intends for and induces its customers to infringe the Asserted Claims under Section 271(b) through the customers' normal and customary use of the Accused Instrumentalities. In addition, Defendant is contributorily infringing the Asserted Claims under Section 271(c) and/or Section 271(f) by selling, offering for sale, or importing the Accused Instrumentalities into the United States, which constitute a material part of the inventions claimed in the Asserted Claims, are especially made or adapted to infringe the Asserted Claims, and are otherwise not staple articles or commodities of commerce suitable for non-infringing use.

E. Patent Rule 3-1(e): Priority Dates

The Asserted Claims of the '814 patent are entitled to a priority date at least as early as September 15, 2003, the filing date of provisional application No. 60/502,619.

The Asserted Claims of the '058 patent are entitled to a priority date at least as early as September 22, 2003, the filing date of provisional application No. 60/504,213.

A diligent search continues for additional responsive information and VirtaMove reserves the right to supplement this response.

F. Patent Rule 3-1(f): Identification of Instrumentalities Practicing the Claimed Invention

At this time, VirtaMove does not identify any of its instrumentalities as practicing the Asserted Claims. A diligent search continues for additional responsive information and VirtaMove reserves the right to supplement this response.

II. Patent Rule 3-2: Document Production Accompanying Disclosure

Pursuant to Patent Rule 3-2, VirtaMove submitted the following Document Production Accompanying Disclosure, along with an identification of the categories to which each of the documents corresponds.

F. Patent Rule 3-2(a) documents:

VirtaMove is presently unaware of any documents sufficient to evidence any discussion with, disclosure to, or other manner of providing to a third party, or sale of or offer to sell, the inventions recited in the Asserted Claims of the Asserted Patents prior to the application dates or priority dates for the Asserted Patents. A diligent search continues for such documents and VirtaMove reserves the right to supplement this response.

G. Patent Rule 3-2(b) documents:

VirtaMove identifies the following non-privileged documents as related to evidencing conception and reduction to practice of each claimed invention of the Asserted Patents: VM_HPE_0000865–VM_HPE_0000880. A diligent search continues for additional documents and VirtaMove reserves the right to supplement this response.

H. Patent Rule 3-2(c) documents:

VirtaMove identifies the following documents as being the file histories for the Asserted Patents: VM_HPE_0000001–VM_HPE_0000864.

Dated: July 1, 2024

Respectfully submitted,

/s/ Reza Mirzaie

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CERTIFICATE OF SERVICE

I certify that this document is being served upon counsel of record for Defendants on July 1, 2024 via e-mail.

/s/ Reza Mirzaie
Reza Mirzaie

U.S. Patent No. 7,519,814 ("'814 Patent")

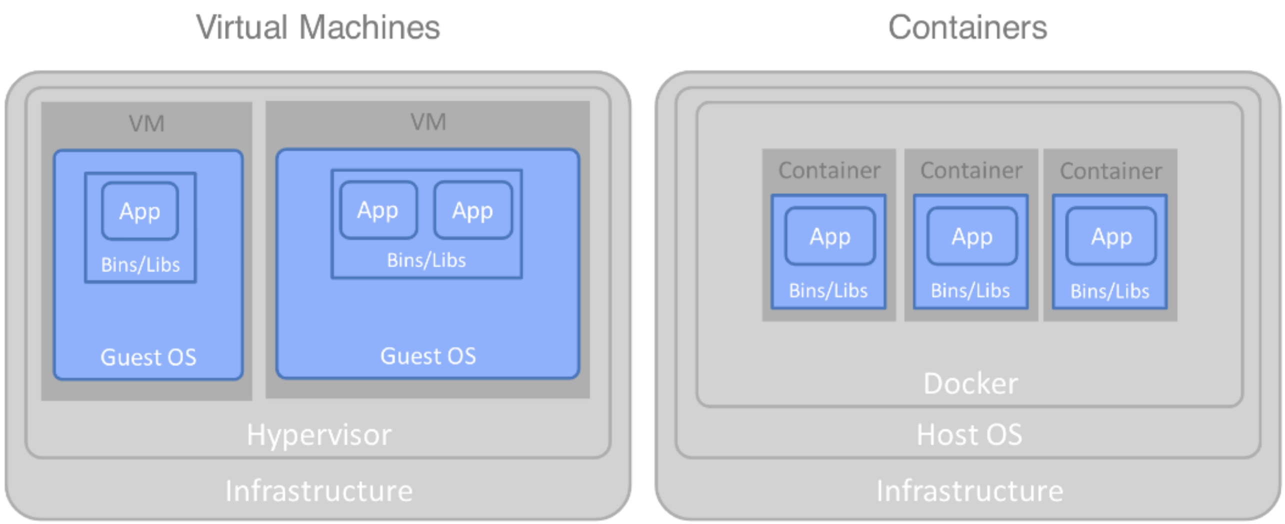
Accused Instrumentalities: IBM products and services using secure containerized applications, including without limitation IBM's Cloud Kubernetes Service (IKS), IBM Cloud Private (ICP), and IBM Hybrid Cloud mesh, and all versions and variations thereof since the issuance of the asserted patent.

Each Accused Instrumentality infringes the claims in substantially the same way, and the evidence shown in this chart is similarly applicable to each Accused Instrumentality. Each claim limitation is literally infringed by each Accused Instrumentality. However, to the extent any claim limitation is not met literally, it is nonetheless met under the doctrine of equivalents because the differences between the claim limitation and each Accused Instrumentality would be insubstantial, and each Accused Instrumentality performs substantially the same function, in substantially the same way, to achieve the same result as the claimed invention. Notably, Defendant has not yet articulated which, if any, particular claim limitations it believes are not met by the Accused Instrumentalities.

Claim 1

Claim 1	Accused Instrumentalities
[1pre] 1. In a system having a plurality of servers with operating systems that differ, operating in disparate computing environments, wherein each server includes a processor and an operating system including a kernel a set of associated local system files compatible with the processor, a method of providing at least some of the servers in the system with secure, executable, applications related to a service, wherein the applications are executed in a secure environment, wherein the applications each	To the extent the preamble is limiting, IBM practices, through the Accused Instrumentalities, in a system having a plurality of servers with operating systems that differ, operating in disparate computing environments, wherein each server includes a processor and an operating system including a kernel a set of associated local system files compatible with the processor, a method of providing at least some of the servers in the system with secure, executable, applications related to a service, wherein the applications are executed in a secure environment, wherein the applications each include an object executable by at least some of the different operating systems for performing a task related to the service, as claimed. For example, IBM Cloud Kubernetes Service runs on individual servers, each of which runs an independent operating system running either on bare metal, through an on-premises virtualized infrastructure, through one or more cloud services, or through any other supported deployment. *See* claim limitations below. *See also, e.g.*:

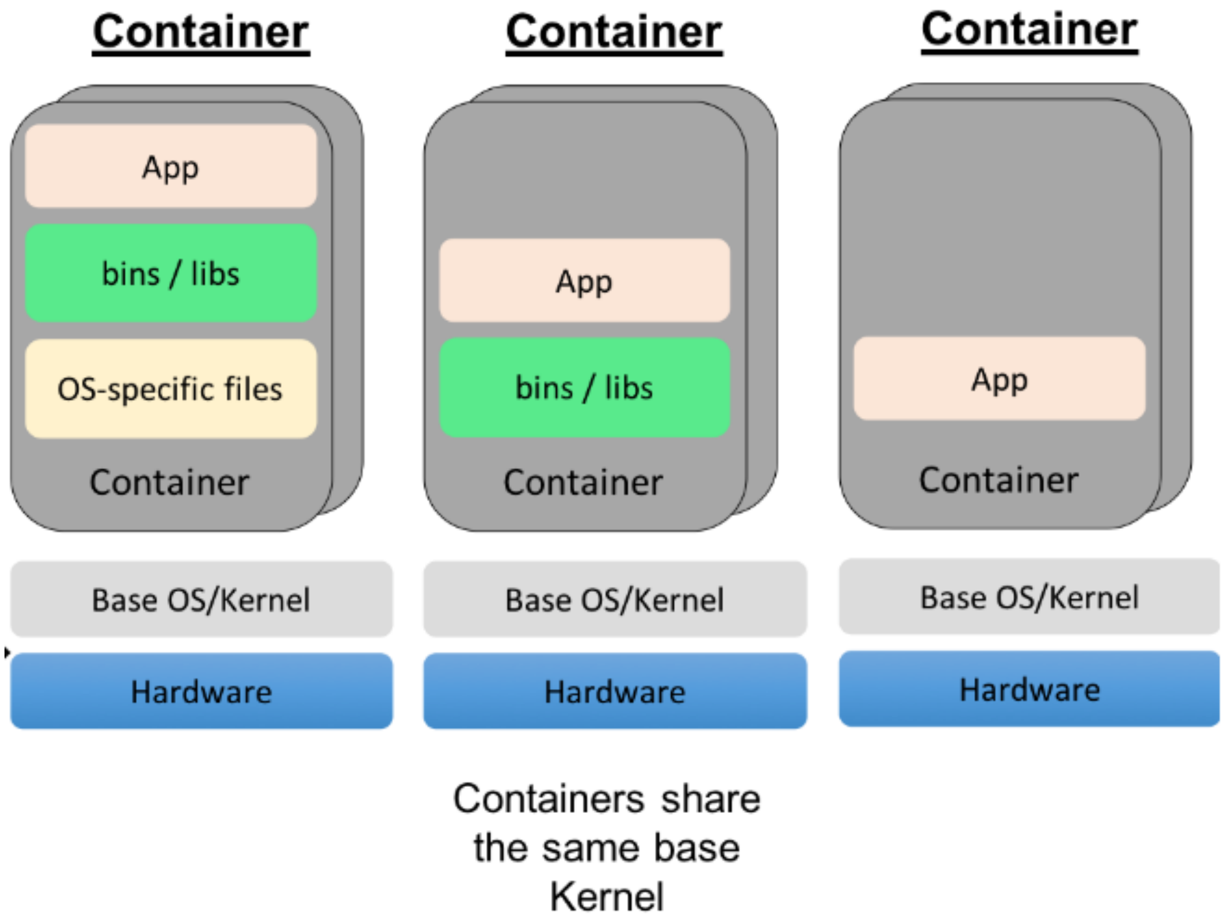
Claim 1	Accused Instrumentalities
include an object executable by at least some of the different operating systems for performing a task related to the service, the method comprising:	IBM Cloud® Kubernetes Service provides a fully managed container service for Docker (OCI) containers, so clients can deploy containerized apps onto a pool of compute hosts and subsequently manage those containers. Containers are automatically scheduled and placed onto available compute hosts based on your requirements and availability in the cluster. https://www.ibm.com/products/kubernetes-service With IBM Cloud Kubernetes Service, you can deploy Docker containers into pods that run on your worker nodes. The worker nodes come with a set of add-on pods to help you manage your containers. Install more add-ons through Helm, a Kubernetes package manager. These add-ons can extend your apps with dashboards, logging, IBM Cloud and IBM Watson® services and more. https://www.ibm.com/products/kubernetes-service Docker is an open source platform that enables developers to build, deploy, run, update and manage *containers*—standardized, executable components that combine application source code with the operating system (OS) libraries and dependencies required to run that code in any environment. https://www.ibm.com/topics/docker

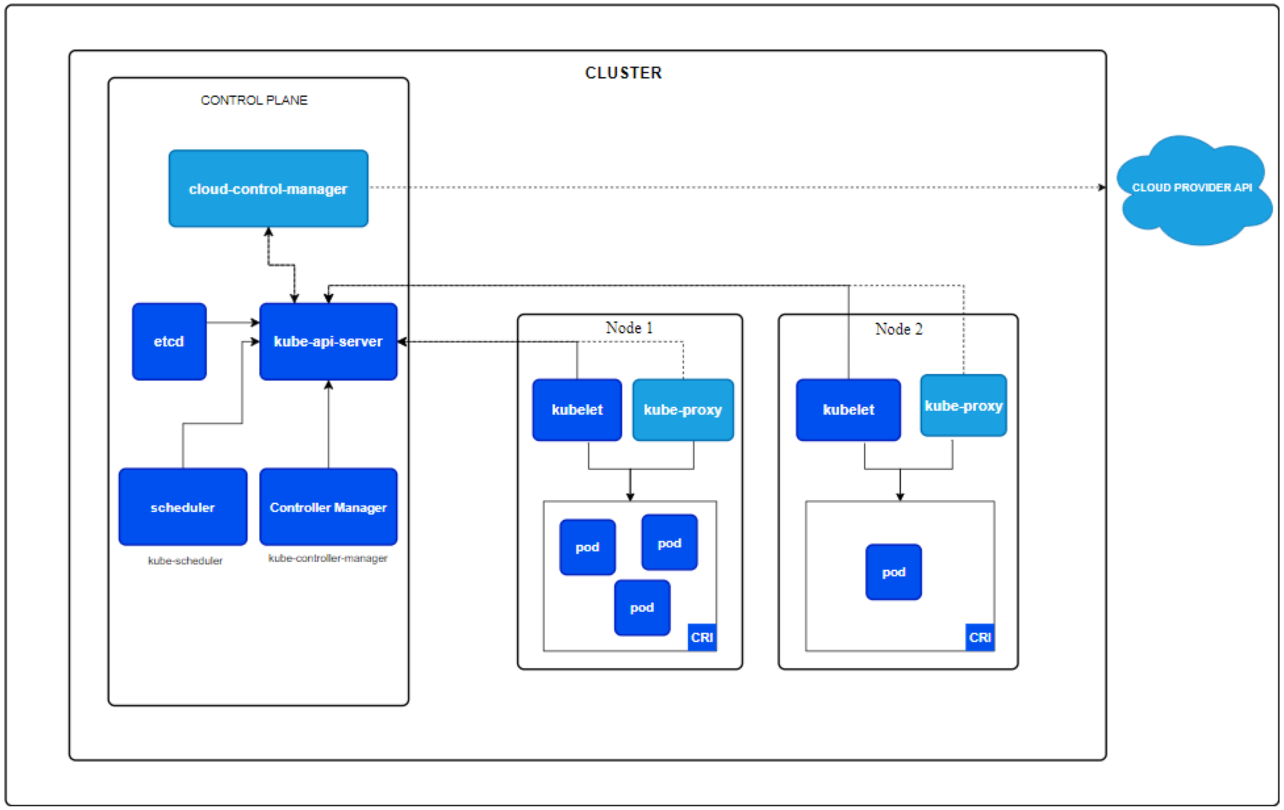
Claim 1	Accused Instrumentalities
	 https://developer.ibm.com/articles/true-benefits-of-moving-to-containers-1/

Claim 1	Accused Instrumentalities
	Containers are executable units of software in which application code is packaged along with its libraries and dependencies, in common ways so that the code can be run anywhere—whether it be on desktop, traditional IT or the cloud. To do this, containers take advantage of a form of operating system (OS) virtualization in which features of the OS kernel (e.g. Linux namespaces and cgroups, Windows silos and job objects) can be leveraged to isolate processes and control the amount of CPU, memory and disk that those processes can access. Containers are small, fast and portable because unlike a virtual machine, containers do not need to include a guest OS in every instance and can instead simply leverage the features and resources of the host OS. https://www.ibm.com/topics/containers With containers, you can isolate the ecosystem to run an application an any host OS (operating system). Containers can wrap code, runtimes, system tools, system libraries—everything that can be installed on a server. Containers are like virtual machines (VMs), but with a key difference in their architectural approach. Images that run on VMs have a full copy of the guest OS, including the necessary binaries and libraries. Images that run on containers share the OS kernel on the host. The Docker Engine builds and spins images on the containers. The engine is a lightweight container runtime that can run on almost any OS. You can run a container anywhere that a Docker Engine can be installed—on bare metal servers, clouds, and even inside a VM. You can move containers from one environment to another without recoding the application. Containers can help DevOps teams in three ways: • Increase development productivity by reducing the time spent on environment setup • Eliminate issues that are caused by software dependencies • Avoid inconsistencies when applications are run in different environments You can use IBM Cloud Kubernetes Service to run containers on IBM Cloud. https://www.ibm.com/garage/method/practices/run/tool_ibm_container/, last accessed on Nov. 17, 2023.

Claim 1	Accused Instrumentalities
	Containers use a form of operating system (OS) virtualization. Put simply, they leverage features of the host operating system to isolate processes and control the processes' access to CPUs, memory and desk space. https://www.ibm.com/blog/containers-vs-vms/ Today Docker containerization also works with Microsoft Windows and Apple MacOS. Developers can run Docker containers on any operating system, and most leading cloud providers, including Amazon Web Services (AWS), Microsoft Azure, and IBM Cloud offer specific services to help developers build, deploy and run applications containerized with Docker. https://www.ibm.com/topics/docker

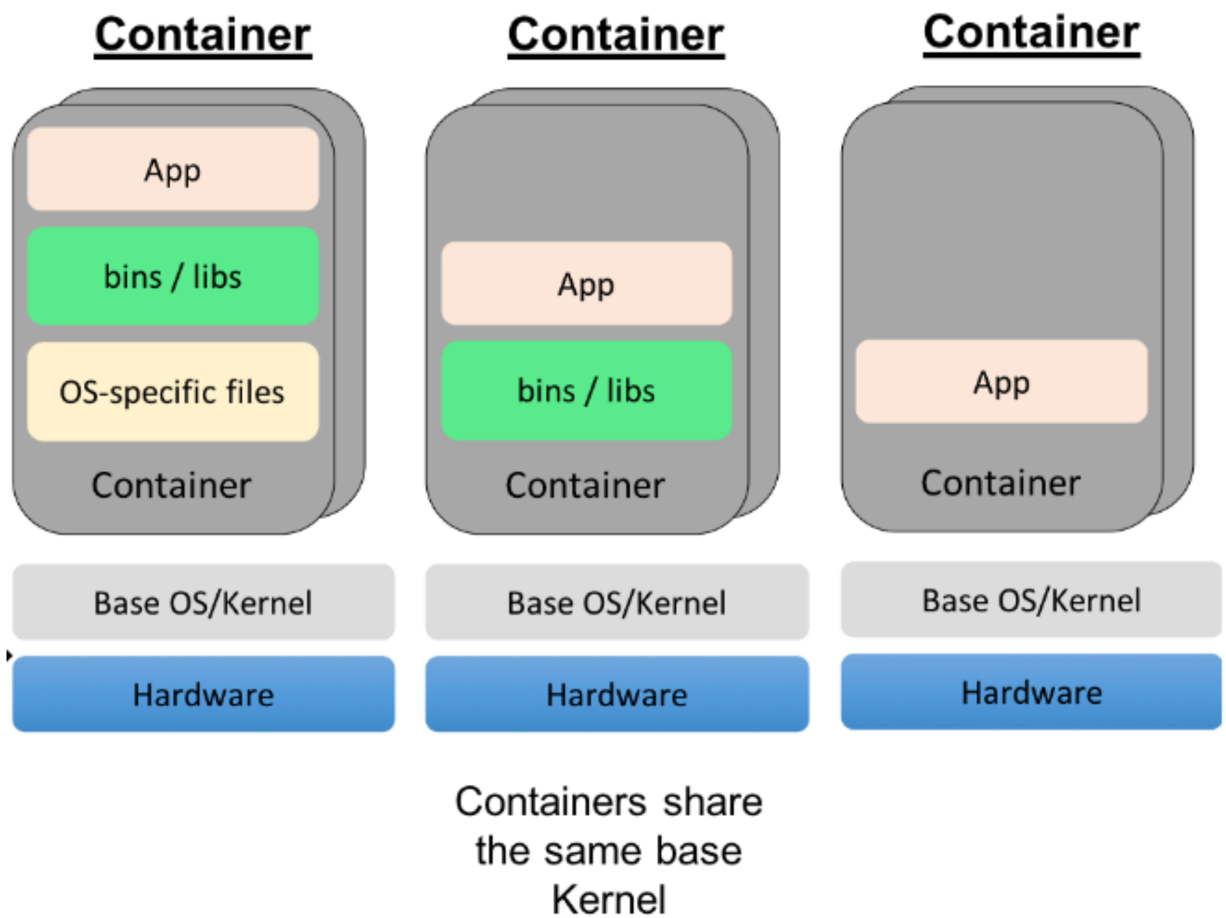
Claim 1	Accused Instrumentalities
	Containers are often referred to as "lightweight," meaning they share the machine's operating system kernel and do not require the overhead of associating an operating system within each application. Containers are inherently smaller in capacity than a VM and require less start-up time, allowing far more containers to run on the same compute capacity as a single VM. This drives higher server efficiencies and, in turn, reduces server and licensing costs. Containers encapsulate an application as a single executable package of software that bundles application code together with all of the related configuration files, libraries, and dependencies required for it to run. Containerized applications are "isolated" in that they do not bundle in a copy of the operating system. Instead, an open source runtime engine (such as the Docker runtime engine) is installed on the host's operating system and becomes the conduit for containers to share an operating system with other containers on the same computing system. https://www.ibm.com/topics/containerization

Claim 1	Accused Instrumentalities
	 https://ibm.github.io/kube101/

<table>
<tr><th>Claim 1</th><th>Accused Instrumentalities</th></tr>
<tr><td></td><td>

Kubernetes cluster architecture
https://kubernetes.io/docs/concepts/architecture/</td></tr>
<tr><td>[1a] storing in memory accessible to at least some of the servers a plurality of secure containers of application software, each container</td><td>The method practiced by IBM through the Accused Instrumentalities includes a step of storing in memory accessible to at least some of the servers a plurality of secure containers of application software, each container comprising one or more of the executable applications and a set of associated system files required to execute the one or more applications, for use with a local kernel residing permanently on one of the servers.</td></tr>
</table>

Claim 1	Accused Instrumentalities
comprising one or more of the executable applications and a set of associated system files required to execute the one or more applications, for use with a local kernel residing permanently on one of the servers;	For example, IBM Cloud Kubernetes stores application containers, sometimes called Docker containers, container images, Kubernetes containers, or Kubernetes pods, in persistent storage available to each node running the application. The container might be in a format defined by the Open Container Initiative. This storage may be physically attached to the server or connected through any supported interconnect, including over a network. Each container includes the application software as well as a Linux user space required to execute the application, for example libc/glibc and other shared libraries, configuration files, etc. necessary for the application. For example, the container includes a base OS image, provided by IBM or by a third party, such as a CentOS, RHEL, or Ubuntu base image. The container is compatible with the host kernel, for example because the container libraries are linked against the Linux kernel, and the supported host operating systems also use the Linux kernel, which has a stable binary interface. *See, e.g.*: Containers use a form of operating system (OS) virtualization. Put simply, they leverage features of the host operating system to isolate processes and control the processes' access to CPUs, memory and desk space. https://www.ibm.com/blog/containers-vs-vms/ Today Docker containerization also works with Microsoft Windows and Apple MacOS. Developers can run Docker containers on any operating system, and most leading cloud providers, including Amazon Web Services (AWS), Microsoft Azure, and IBM Cloud offer specific services to help developers build, deploy and run applications containerized with Docker. https://www.ibm.com/topics/docker

Claim 1	Accused Instrumentalities
	 https://ibm.github.io/kube101/

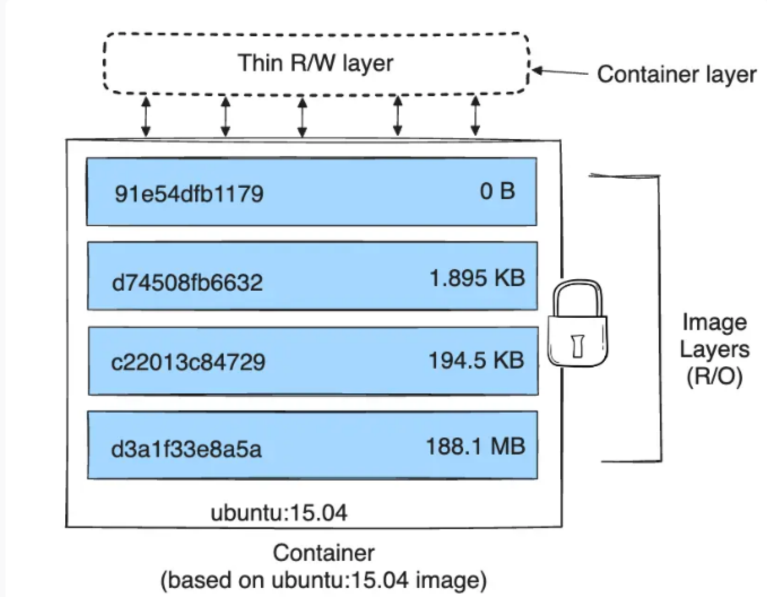
Claim 1	Accused Instrumentalities
	Container images A container image is a ready-to-run software package containing everything needed to run an application: the code and any runtime it requires, application and system libraries, and default values for any essential settings. https://kubernetes.io/docs/concepts/containers/ A Docker image is the basis for every container that you create with IBM Cloud® Kubernetes Service. An image is created from a Dockerfile, which is a file that contains instructions to build the image. A Dockerfile might reference build artifacts in its instructions that are stored separately, such as an app, the app's configuration, and its dependencies. https://cloud.ibm.com/docs/containers?topic=containers-images

Claim 1	Accused Instrumentalities
	<table><tr><th>Docker base image</th><th>Supported versions</th><th>Source of security notices</th></tr><tr><td>Alpine</td><td>All stable versions with vendor security support.</td><td>Alpine SecDB database.</td></tr><tr><td>Debian</td><td>All stable versions with vendor security support. CVEs on binary packages that are associated with the Debian source package `linux`, such as `linux-libc-dev`, are not reported. Most of these binary packages are kernel and kernel modules, which are not run in container images.</td><td>Debian Security Bug Tracker.</td></tr><tr><td>GoogleContainerTools distroless</td><td>All stable versions with vendor security support.</td><td>GoogleContainerTools distroless</td></tr><tr><td>Red Hat® Enterprise Linux® (RHEL)</td><td>RHEL/UBI 7, RHEL/UBI 8, and RHEL/UBI 9</td><td>Red Hat Security Data API.</td></tr><tr><td>Ubuntu</td><td>All stable versions with vendor security support.</td><td>Ubuntu CVE Tracker.</td></tr></table> https://cloud.ibm.com/docs/Registry?topic=Registry-va_index&interface=ui

Claim 1	Accused Instrumentalities
	# About storage drivers To use storage drivers effectively, it's important to know how Docker builds and stores images, and how these images are used by containers. You can use this information to make informed choices about the best way to persist data from your applications and avoid performance problems along the way. ## Storage drivers versus Docker volumes Docker uses storage drivers to store image layers, and to store data in the writable layer of a container. The container's writable layer doesn't persist after the container is deleted, but is suitable for storing ephemeral data that is generated at runtime. Storage drivers are optimized for space efficiency, but (depending on the storage driver) write speeds are lower than native file system performance, especially for storage drivers that use a copy-on-write filesystem. Write-intensive applications, such as database storage, are impacted by a performance overhead, particularly if pre-existing data exists in the read-only layer. Use Docker volumes for write-intensive data, data that must persist beyond the container's lifespan, and data that must be shared between containers. Refer to the volumes section to learn how to use volumes to persist data and improve performance. https://docs.docker.com/storage/storagedriver/

Claim 1	Accused Instrumentalities

	Images and layers
	
	A Docker image is built up from a series of layers. Each layer represents an instruction in the image's Dockerfile. Each layer except the very last one is read-only. Consider the following Dockerfile:
	
	`# syntax=docker/dockerfile:1`
	
	`FROM ubuntu:22.04`
	`LABEL org.opencontainers.image.authors="org@example.com"`
	`COPY . /app`
	`RUN make /app`
	`RUN rm -r $HOME/.cache`
	`CMD python /app/app.py`
	
	This Dockerfile contains four commands. Commands that modify the filesystem create a layer. The `FROM` statement starts out by creating a layer from the `ubuntu:22.04` image. The `LABEL` command only modifies the image's metadata, and doesn't produce a new layer. The `COPY` command adds some files from your Docker client's current directory. The first `RUN` command builds your application using the `make` command, and writes the result to a new layer. The second `RUN` command removes a cache directory, and writes the result to a new layer. Finally, the `CMD` instruction specifies what command to run within the container, which only modifies the image's metadata, which doesn't produce an image layer.
	
	https://docs.docker.com/storage/storagedriver/

	Each layer is only a set of differences from the layer before it. Note that both *adding*, and *removing* files will result in a new layer. In the example above, the `$HOME/.cache` directory is removed, but will still be available in the previous layer and add up to the image's total size. Refer to the Best practices for writing Dockerfiles and use multi-stage builds sections to learn how to optimize your Dockerfiles for efficient images. The layers are stacked on top of each other. When you create a new container, you add a new writable layer on top of the underlying layers. This layer is often called the "container layer". All changes made to the running container, such as writing new files, modifying existing files, and deleting files, are written to this thin writable container layer. The diagram below shows a container based on an `ubuntu:15.04` image.  https://docs.docker.com/storage/storagedriver/

Claim 1	Accused Instrumentalities
	Volumes Volumes are the preferred mechanism for persisting data generated by and used by Docker containers. While bind mounts are dependent on the directory structure and OS of the host machine, volumes are completely managed by Docker. Volumes have several advantages over bind mounts: https://kubernetes.io/docs/concepts/storage/volumes/ **Container environment** The Kubernetes Container environment provides several important resources to Containers: • A filesystem, which is a combination of an image and one or more volumes. • Information about the Container itself. • Information about other objects in the cluster. https://kubernetes.io/docs/concepts/containers/container-environment/

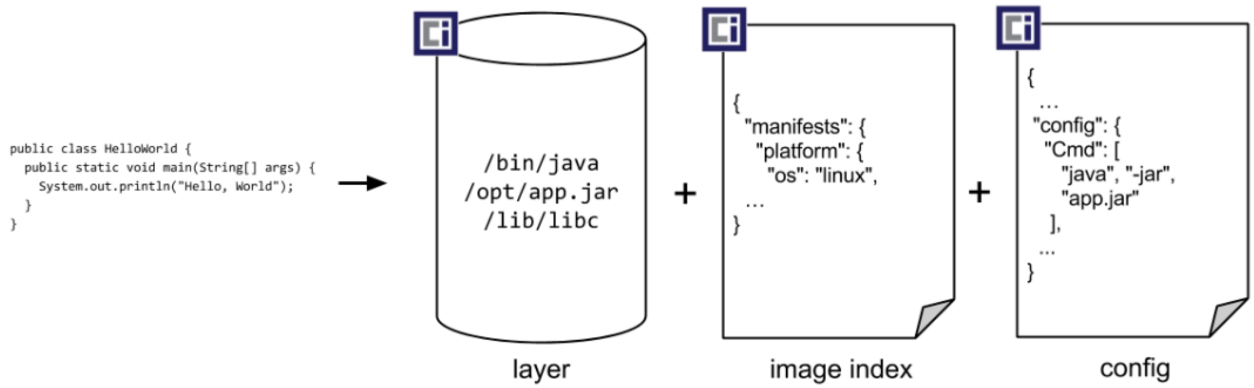
Claim 1	Accused Instrumentalities
	Images A container image represents binary data that encapsulates an application and all its software dependencies. Container images are executable software bundles that can run standalone and that make very well defined assumptions about their runtime environment. You typically create a container image of your application and push it to a registry before referring to it in a Pod. https://kubernetes.io/docs/concepts/containers/images/ **Volumes** On-disk files in a container are ephemeral, which presents some problems for non-trivial applications when running in containers. One problem occurs when a container crashes or is stopped. Container state is not saved so all of the files that were created or modified during the lifetime of the container are lost. During a crash, kubelet restarts the container with a clean state. Another problem occurs when multiple containers are running in a `Pod` and need to share files. It can be challenging to setup and access a shared filesystem across all of the containers. The Kubernetes volume abstraction solves both of these problems. Familiarity with Pods is suggested. https://kubernetes.io/docs/concepts/storage/volumes/

Claim 1	Accused Instrumentalities
	# Open Container Initiative ## Image Format Specification This specification defines an OCI Image, consisting of an image manifest, an image index (optional), a set of filesystem layers, and a configuration. The goal of this specification is to enable the creation of interoperable tools for building, transporting, and preparing a container image to run. https://github.com/opencontainers/image-spec/blob/a6af2b480dcfc001ba975f44de53001c873cb0ef/spec.md

<table>
<tr><th>Claim 1</th><th>Accused Instrumentalities</th></tr>
<tr><td></td><td>

Overview

At a high level the image manifest contains metadata about the contents and dependencies of the image including the content-addressable identity of one or more filesystem layer changeset archives that will be unpacked to make up the final runnable filesystem. The image configuration includes information such as application arguments, environments, etc. The image index is a higher-level manifest which points to a list of manifests and descriptors. Typically, these manifests may provide different implementations of the image, possibly varying by platform or other attributes.



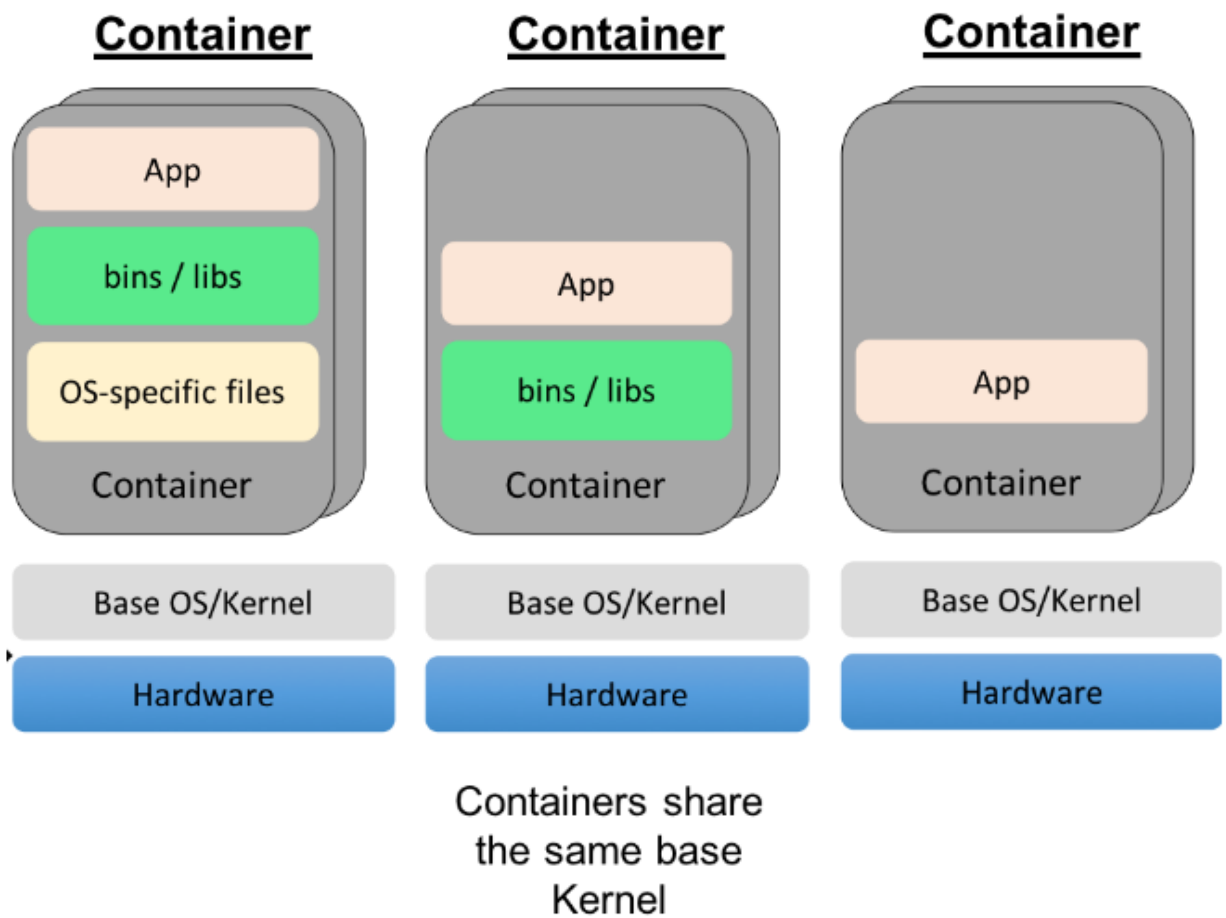
https://github.com/opencontainers/image-spec/blob/a6af2b480dcfc001ba975f44de53001c873cb0ef/spec.md
</td></tr>
</table>

Claim 1	Accused Instrumentalities
	OCI Image Configuration An OCI *Image* is an ordered collection of root filesystem changes and the corresponding execution parameters for use within a container runtime. This specification outlines the JSON format describing images for use with a container runtime and execution tool and its relationship to filesystem changesets, described in Layers. This section defines the `application/vnd.oci.image.config.v1+json` media type. https://github.com/opencontainers/image-spec/blob/a6af2b480dcfc001ba975f44de53001c873cb0ef/config.md

Claim 1	Accused Instrumentalities
	Layer • Image filesystems are composed of *layers*. • Each layer represents a set of filesystem changes in a tar-based layer format, recording files to be added, changed, or deleted relative to its parent layer. • Layers do not have configuration metadata such as environment variables or default arguments - these are properties of the image as a whole rather than any particular layer. • Using a layer-based or union filesystem such as AUFS, or by computing the diff from filesystem snapshots, the filesystem changeset can be used to present a series of image layers as if they were one cohesive filesystem. **Image JSON** • Each image has an associated JSON structure which describes some basic information about the image such as date created, author, as well as execution/runtime configuration like its entrypoint, default arguments, networking, and volumes. • The JSON structure also references a cryptographic hash of each layer used by the image, and provides history information for those layers. • This JSON is considered to be immutable, because changing it would change the computed ImageID. • Changing it means creating a new derived image, instead of changing the existing image. https://github.com/opencontainers/image-spec/blob/a6af2b480dcfc001ba975f44de53001c873cb0ef/config.md

Claim 1	Accused Instrumentalities
	• **rootfs** *object*, REQUIRED The rootfs key references the layer content addresses used by the image. This makes the image config hash depend on the filesystem hash. ◦ **type** *string*, REQUIRED MUST be set to `layers`. Implementations MUST generate an error if they encounter a unknown value while verifying or unpacking an image. ◦ **diff_ids** *array of strings*, REQUIRED An array of layer content hashes (`DiffIDs`), in order from first to last. https://github.com/opencontainers/image-spec/blob/a6af2b480dcfc001ba975f44de53001c873cb0ef/config.md
[1b] wherein the set of associated system files are compatible with a local kernel of at least some of the plurality of different operating systems,	In the method practiced by IBM through the Accused Instrumentalities, the set of associated system files are compatible with a local kernel of at least some of the plurality of different operating systems. The system files in the container are compatible with the host kernel, for example because they are linked against the Linux kernel and the supported host operating systems also use the Linux kernel, which has a stable binary interface. *See, e.g.*:

Claim 1	Accused Instrumentalities
	Containers are often referred to as "lightweight," meaning they share the machine's operating system kernel and do not require the overhead of associating an operating system within each application. Containers are inherently smaller in capacity than a VM and require less start-up time, allowing far more containers to run on the same compute capacity as a single VM. This drives higher server efficiencies and, in turn, reduces server and licensing costs. Containers encapsulate an application as a single executable package of software that bundles application code together with all of the related configuration files, libraries, and dependencies required for it to run. Containerized applications are "isolated" in that they do not bundle in a copy of the operating system. Instead, an open source runtime engine (such as the Docker runtime engine) is installed on the host's operating system and becomes the conduit for containers to share an operating system with other containers on the same computing system. https://www.ibm.com/topics/containerization

Claim 1	Accused Instrumentalities
	 https://ibm.github.io/kube101/

Claim 1	Accused Instrumentalities
	A Docker image is the basis for every container that you create with IBM Cloud® Kubernetes Service. An image is created from a Dockerfile, which is a file that contains instructions to build the image. A Dockerfile might reference build artifacts in its instructions that are stored separately, such as an app, the app's configuration, and its dependencies. https://cloud.ibm.com/docs/containers?topic=containers-images

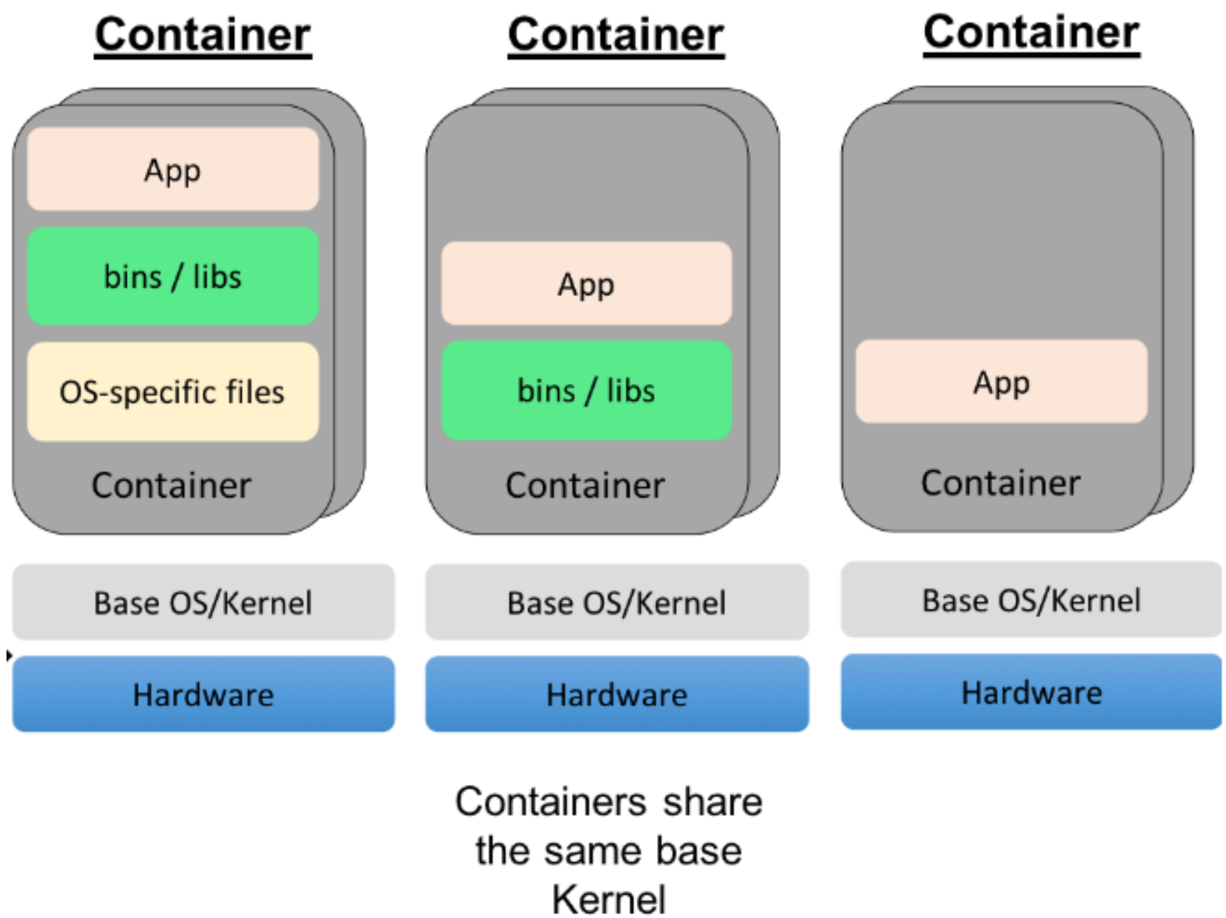
<table>
<tr><th>Claim 1</th><th>Accused Instrumentalities</th></tr>
<tr><td></td><td>
<table>
<tr><th>Docker base image</th><th>Supported versions</th><th>Source of security notices</th></tr>
<tr><td>Alpine</td><td>All stable versions with vendor security support.</td><td>Alpine SecDB database .</td></tr>
<tr><td>Debian</td><td>All stable versions with vendor security support.

CVEs on binary packages that are associated with the Debian source package `linux`, such as `linux-libc-dev`, are not reported. Most of these binary packages are kernel and kernel modules, which are not run in container images.</td><td>Debian Security Bug Tracker .</td></tr>
<tr><td>GoogleContainerTools distroless</td><td>All stable versions with vendor security support.</td><td>GoogleContainerTools distroless</td></tr>
<tr><td>Red Hat® Enterprise Linux® (RHEL)</td><td>RHEL/UBI 7, RHEL/UBI 8, and RHEL/UBI 9</td><td>Red Hat Security Data API .</td></tr>
<tr><td>Ubuntu</td><td>All stable versions with vendor security support.</td><td>Ubuntu CVE Tracker .</td></tr>
</table>

https://cloud.ibm.com/docs/Registry?topic=Registry-va_index&interface=ui
</td></tr>
<tr><td>[1c] the containers of application software excluding a kernel,</td><td>In the method practiced by IBM through the Accused Instrumentalities, the containers of application software exclude a kernel.

See, e.g.:</td></tr>
</table>

Claim 1	Accused Instrumentalities
	Containers are often referred to as "lightweight," meaning they share the machine's operating system kernel and do not require the overhead of associating an operating system within each application. Containers are inherently smaller in capacity than a VM and require less start-up time, allowing far more containers to run on the same compute capacity as a single VM. This drives higher server efficiencies and, in turn, reduces server and licensing costs. https://www.ibm.com/topics/containerization

Claim 1	Accused Instrumentalities
	 https://ibm.github.io/kube101/
[1d] wherein some or all of the associated system files within a container stored in memory are utilized in place of the	In the method practiced by IBM through the Accused Instrumentalities, some or all of the associated system files within a container stored in memory are utilized in place of the associated local system files that remain resident on the server.

Claim 1	Accused Instrumentalities
associated local system files that remain resident on the server,	For example, each container will utilize its own local system files, including libraries such as libc/glibc and configuration files, not the corresponding libraries and configuration files of the host OS. *See, e.g.*: Rather than spinning up an entire virtual machine, containerization packages together everything needed to run a single application or microservice (along with runtime libraries they need to run). The container includes all the code, its dependencies and even the operating system itself. This enables applications to run almost anywhere — a desktop computer, a traditional IT infrastructure or the cloud. Containers use a form of operating system (OS) virtualization. Put simply, they leverage features of the host operating system to isolate processes and control the processes' access to CPUs, memory and desk space. https://www.ibm.com/blog/containers-vs-vms/
[1e] wherein said associated system files utilized in place of the associated local system files are copies or modified copies of the associated local system files that remain resident on the server,	In the method practiced by IBM through the Accused Instrumentalities, said associated system files utilized in place of the associated local system files are copies or modified copies of the associated local system files that remain resident on the server. For example, in some cases the host OS and container will use one or more identical system files, for example when both the host and the container incorporate the same Linux distribution version, or when both host and container use the same version of libc. In other cases modified copies are used instead, for example when different versions of the same library, or configuration files with different parameters, are used by the host and container. *See, e.g.*:

Claim 1	Accused Instrumentalities
	Containerization is the packaging of software code with just the operating system (OS) libraries and dependencies required to run the code to create a single lightweight executable—called a container—that runs consistently on any infrastructure. More portable and resource-efficient than virtual machines (VMs), containers have become the de facto compute units of modern cloud-native applications. Containerization allows developers to create and deploy applications faster and more securely. With traditional methods, code is developed in a specific computing environment which, when transferred to a new location, often results in bugs and errors. For example, when a developer transfers code from a desktop computer to a VM or from a Linux to a Windows operating system. Containerization eliminates this problem by bundling the application code together with the related configuration files, libraries, and dependencies required for it to run. This single package of software or "container" is abstracted away from the host operating system, and hence, it stands alone and becomes portable—able to run across any platform or cloud, free of issues. https://www.ibm.com/topics/containerization

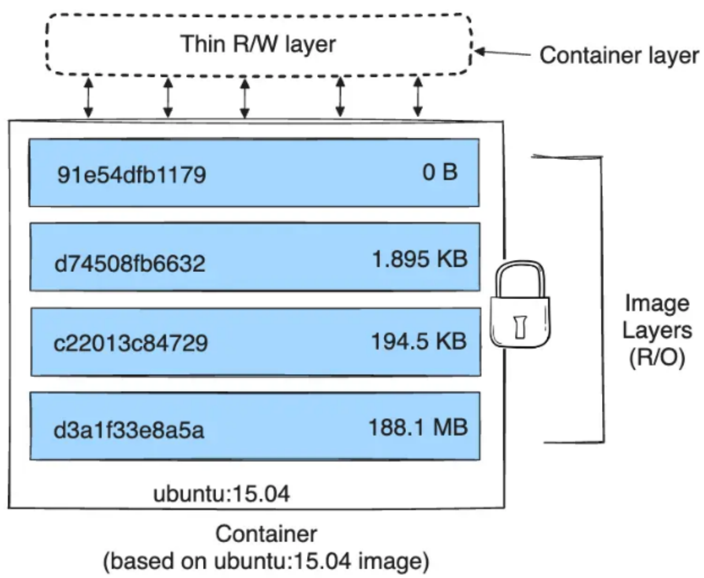
Claim 1	Accused Instrumentalities
	With containers, you can isolate the ecosystem to run an application an any host OS (operating system). Containers can wrap code, runtimes, system tools, system libraries—everything that can be installed on a server. Containers are like virtual machines (VMs), but with a key difference in their architectural approach. Images that run on VMs have a full copy of the guest OS, including the necessary binaries and libraries. Images that run on containers share the OS kernel on the host. The Docker Engine builds and spins images on the containers. The engine is a lightweight container runtime that can run on almost any OS. You can run a container anywhere that a Docker Engine can be installed—on bare metal servers, clouds, and even inside a VM. You can move containers from one environment to another without recoding the application. Containers can help DevOps teams in three ways: • Increase development productivity by reducing the time spent on environment setup • Eliminate issues that are caused by software dependencies • Avoid inconsistencies when applications are run in different environments You can use IBM Cloud Kubernetes Service to run containers on IBM Cloud. https://www.ibm.com/garage/method/practices/run/tool_ibm_container/, last accessed on Nov. 17, 2023.
[1f] and wherein the application software cannot be shared between the plurality of secure containers of application software,	In the method practiced by IBM through the Accused Instrumentalities, the application software cannot be shared between the plurality of secure containers of application software. For example, each container has an isolated runtime environment that cannot be accessed by other containers, for example including a per-container writeable layer or other ephemeral per-container storage. For another example, when the plurality of secure containers each corresponds to a different container image, each container cannot access another container's image and therefore application software. *See, e.g.*: Containers are made possible by process isolation and virtualization capabilities built into the Linux kernel. These capabilities—such as *control groups* (Cgroups) for allocating resources among processes, and *namespaces* for restricting a processes access or visibility into other resources or areas of the system—enable multiple application components to share the resources of a single instance of the host operating system in much the same way that a hypervisor enables multiple virtual machines (VMs) to share the CPU, memory and other resources of a single hardware server. https://www.ibm.com/topics/docker

Claim 1	Accused Instrumentalities
	Fault isolation: Each containerized application is isolated and operates independently of others. The failure of one container does not affect the continued operation of any other containers. Development teams can identify and correct any technical issues within one container without any downtime in other containers. Also, the container engine can leverage any OS security isolation techniques—such as SELinux access control—to isolate faults within containers. https://www.ibm.com/topics/containerization

Claim 1	Accused Instrumentalities
	About storage drivers To use storage drivers effectively, it's important to know how Docker builds and stores images, and how these images are used by containers. You can use this information to make informed choices about the best way to persist data from your applications and avoid performance problems along the way. **Storage drivers versus Docker volumes** Docker uses storage drivers to store image layers, and to store data in the writable layer of a container. The container's writable layer doesn't persist after the container is deleted, but is suitable for storing ephemeral data that is generated at runtime. Storage drivers are optimized for space efficiency, but (depending on the storage driver) write speeds are lower than native file system performance, especially for storage drivers that use a copy-on-write filesystem. Write-intensive applications, such as database storage, are impacted by a performance overhead, particularly if pre-existing data exists in the read-only layer. Use Docker volumes for write-intensive data, data that must persist beyond the container's lifespan, and data that must be shared between containers. Refer to the volumes section to learn how to use volumes to persist data and improve performance. https://docs.docker.com/storage/storagedriver/

Claim 1	Accused Instrumentalities

	Images and layers
	
	A Docker image is built up from a series of layers. Each layer represents an instruction in the image's Dockerfile. Each layer except the very last one is read-only. Consider the following Dockerfile:
	
	`# syntax=docker/dockerfile:1`
	
	`FROM ubuntu:22.04`
	`LABEL org.opencontainers.image.authors="org@example.com"`
	`COPY . /app`
	`RUN make /app`
	`RUN rm -r $HOME/.cache`
	`CMD python /app/app.py`
	
	This Dockerfile contains four commands. Commands that modify the filesystem create a layer. The `FROM` statement starts out by creating a layer from the `ubuntu:22.04` image. The `LABEL` command only modifies the image's metadata, and doesn't produce a new layer. The `COPY` command adds some files from your Docker client's current directory. The first `RUN` command builds your application using the `make` command, and writes the result to a new layer. The second `RUN` command removes a cache directory, and writes the result to a new layer. Finally, the `CMD` instruction specifies what command to run within the container, which only modifies the image's metadata, which doesn't produce an image layer.
	
	https://docs.docker.com/storage/storagedriver/

	Each layer is only a set of differences from the layer before it. Note that both *adding*, and *removing* files will result in a new layer. In the example above, the `$HOME/.cache` directory is removed, but will still be available in the previous layer and add up to the image's total size. Refer to the Best practices for writing Dockerfiles and use multi-stage builds sections to learn how to optimize your Dockerfiles for efficient images. The layers are stacked on top of each other. When you create a new container, you add a new writable layer on top of the underlying layers. This layer is often called the "container layer". All changes made to the running container, such as writing new files, modifying existing files, and deleting files, are written to this thin writable container layer. The diagram below shows a container based on an `ubuntu:15.04` image.  https://docs.docker.com/storage/storagedriver/

Claim 1	Accused Instrumentalities
[1g] and wherein each of the containers has a unique root file system that is different from an operating system's root file system.	In the method practiced by IBM through the Accused Instrumentalities, each of the containers has a unique root file system that is different from an operating system's root file system. For example, the container's root file system comprises the image layer(s), an ephemeral writeable layer (e.g., in Docker terminology the container layer), and optionally one or more volumes. This root file system is distinct and isolated from the host operating system's root file system. *See, e.g.*: Limit the number of privileged containers. Containers run as a separate Linux process on the compute host that is isolated from other processes. Although users have root access inside the container, the permissions of this user are limited outside the container to protect other Linux processes, the host file system, and host devices. Some apps require access to the host file system or advanced permissions to run properly. You can run containers in privileged mode to allow the container the same access as the processes running on the compute host. Keep in mind that privileged containers can cause huge damage to the cluster and the underlying compute host if they become compromised. Try to limit the number of containers that run in privileged mode and consider changing the configuration for your app so that the app can run without advanced permissions. https://cloud.ibm.com/docs/containers?topic=containers-security Containers are made possible by process isolation and virtualization capabilities built into the Linux kernel. These capabilities—such as *control groups* (Cgroups) for allocating resources among processes, and *namespaces* for restricting a processes access or visibility into other resources or areas of the system—enable multiple application components to share the resources of a single instance of the host operating system in much the same way that a hypervisor enables multiple virtual machines (VMs) to share the CPU, memory and other resources of a single hardware server. https://www.ibm.com/topics/docker

<table>
<tr><th>Claim 1</th><th>Accused Instrumentalities</th></tr>
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About storage drivers

To use storage drivers effectively, it's important to know how Docker builds and stores images, and how these images are used by containers. You can use this information to make informed choices about the best way to persist data from your applications and avoid performance problems along the way.

Storage drivers versus Docker volumes

Docker uses storage drivers to store image layers, and to store data in the writable layer of a container. The container's writable layer doesn't persist after the container is deleted, but is suitable for storing ephemeral data that is generated at runtime. Storage drivers are optimized for space efficiency, but (depending on the storage driver) write speeds are lower than native file system performance, especially for storage drivers that use a copy-on-write filesystem. Write-intensive applications, such as database storage, are impacted by a performance overhead, particularly if pre-existing data exists in the read-only layer.

Use Docker volumes for write-intensive data, data that must persist beyond the container's lifespan, and data that must be shared between containers. Refer to the volumes section to learn how to use volumes to persist data and improve performance.

https://docs.docker.com/storage/storagedriver/
</td></tr>
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Claim 1	Accused Instrumentalities

	Images and layers
	
	A Docker image is built up from a series of layers. Each layer represents an instruction in the image's Dockerfile. Each layer except the very last one is read-only. Consider the following Dockerfile:
	
	`# syntax=docker/dockerfile:1`
	
	`FROM ubuntu:22.04`
	`LABEL org.opencontainers.image.authors="org@example.com"`
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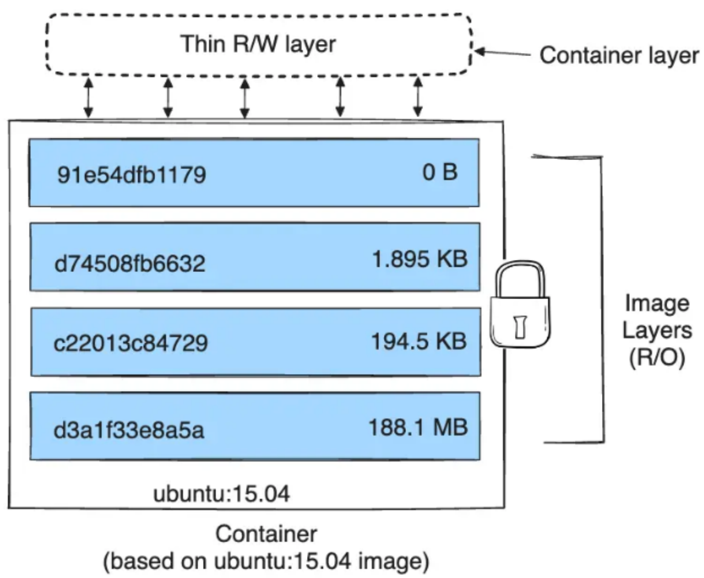
	`RUN make /app`
	`RUN rm -r $HOME/.cache`
	`CMD python /app/app.py`
	
	This Dockerfile contains four commands. Commands that modify the filesystem create a layer. The `FROM` statement starts out by creating a layer from the `ubuntu:22.04` image. The `LABEL` command only modifies the image's metadata, and doesn't produce a new layer. The `COPY` command adds some files from your Docker client's current directory. The first `RUN` command builds your application using the `make` command, and writes the result to a new layer. The second `RUN` command removes a cache directory, and writes the result to a new layer. Finally, the `CMD` instruction specifies what command to run within the container, which only modifies the image's metadata, which doesn't produce an image layer.
	
	https://docs.docker.com/storage/storagedriver/

Each layer is only a set of differences from the layer before it. Note that both *adding*, and *removing* files will result in a new layer. In the example above, the `$HOME/.cache` directory is removed, but will still be available in the previous layer and add up to the image's total size. Refer to the Best practices for writing Dockerfiles and use multi-stage builds sections to learn how to optimize your Dockerfiles for efficient images.

The layers are stacked on top of each other. When you create a new container, you add a new writable layer on top of the underlying layers. This layer is often called the "container layer". All changes made to the running container, such as writing new files, modifying existing files, and deleting files, are written to this thin writable container layer. The diagram below shows a container based on an `ubuntu:15.04` image.



https://docs.docker.com/storage/storagedriver/

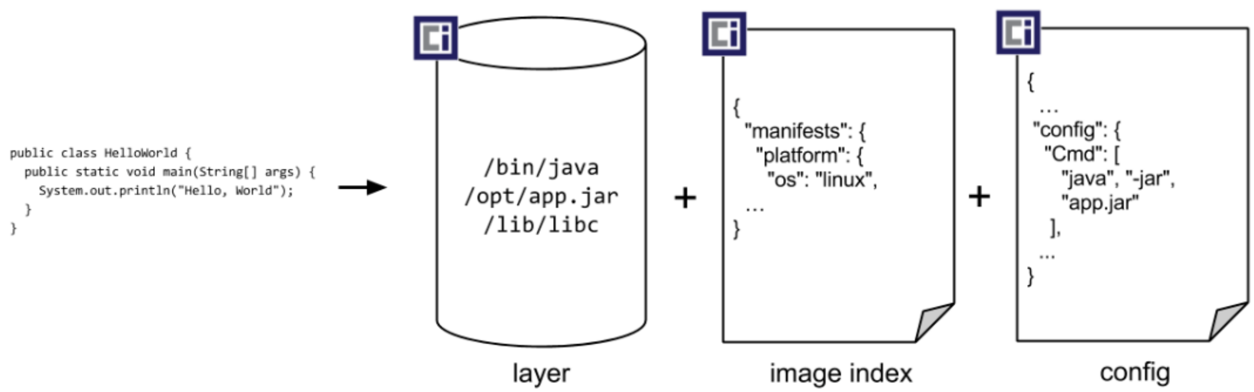
<table>
<tr><th>Claim 1</th><th>Accused Instrumentalities</th></tr>
<tr><td></td><td>
<h1>Volumes</h1>
Volumes are the preferred mechanism for persisting data generated by and used by Docker containers. While bind mounts are dependent on the directory structure and OS of the host machine, volumes are completely managed by Docker. Volumes have several advantages over bind mounts:
https://kubernetes.io/docs/concepts/storage/volumes/
<h2>Container environment</h2>
The Kubernetes Container environment provides several important resources to Containers:

A filesystem, which is a combination of an image and one or more volumes.
Information about the Container itself.
Information about other objects in the cluster.

https://kubernetes.io/docs/concepts/containers/container-environment/
</td></tr>
</table>

Claim 1	Accused Instrumentalities
	Images A container image represents binary data that encapsulates an application and all its software dependencies. Container images are executable software bundles that can run standalone and that make very well defined assumptions about their runtime environment. You typically create a container image of your application and push it to a registry before referring to it in a Pod. https://kubernetes.io/docs/concepts/containers/images/ **Volumes** On-disk files in a container are ephemeral, which presents some problems for non-trivial applications when running in containers. One problem occurs when a container crashes or is stopped. Container state is not saved so all of the files that were created or modified during the lifetime of the container are lost. During a crash, kubelet restarts the container with a clean state. Another problem occurs when multiple containers are running in a `Pod` and need to share files. It can be challenging to setup and access a shared filesystem across all of the containers. The Kubernetes volume abstraction solves both of these problems. Familiarity with Pods is suggested. https://kubernetes.io/docs/concepts/storage/volumes/

Claim 1	Accused Instrumentalities
	# Open Container Initiative ## Image Format Specification This specification defines an OCI Image, consisting of an image manifest, an image index (optional), a set of filesystem layers, and a configuration. The goal of this specification is to enable the creation of interoperable tools for building, transporting, and preparing a container image to run. https://github.com/opencontainers/image-spec/blob/a6af2b480dcfc001ba975f44de53001c873cb0ef/spec.md

Claim 1	Accused Instrumentalities
	Overview At a high level the image manifest contains metadata about the contents and dependencies of the image including the content-addressable identity of one or more filesystem layer changeset archives that will be unpacked to make up the final runnable filesystem. The image configuration includes information such as application arguments, environments, etc. The image index is a higher-level manifest which points to a list of manifests and descriptors. Typically, these manifests may provide different implementations of the image, possibly varying by platform or other attributes.  https://github.com/opencontainers/image-spec/blob/a6af2b480dcfc001ba975f44de53001c873cb0ef/spec.md

Claim 1	Accused Instrumentalities
	# OCI Image Configuration An OCI *Image* is an ordered collection of root filesystem changes and the corresponding execution parameters for use within a container runtime. This specification outlines the JSON format describing images for use with a container runtime and execution tool and its relationship to filesystem changesets, described in Layers. This section defines the `application/vnd.oci.image.config.v1+json` media type. https://github.com/opencontainers/image-spec/blob/a6af2b480dcfc001ba975f44de53001c873cb0ef/config.md

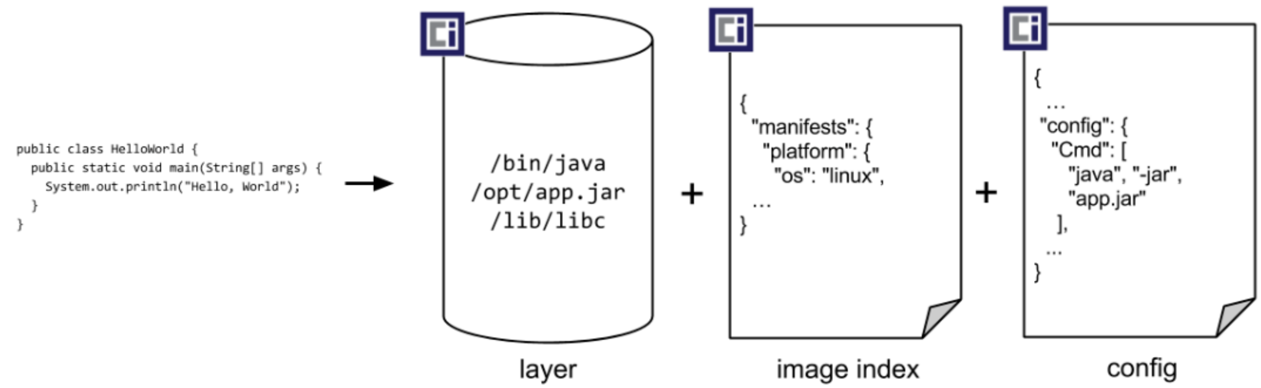
Claim 1	Accused Instrumentalities
	Layer • Image filesystems are composed of *layers*. • Each layer represents a set of filesystem changes in a tar-based layer format, recording files to be added, changed, or deleted relative to its parent layer. • Layers do not have configuration metadata such as environment variables or default arguments - these are properties of the image as a whole rather than any particular layer. • Using a layer-based or union filesystem such as AUFS, or by computing the diff from filesystem snapshots, the filesystem changeset can be used to present a series of image layers as if they were one cohesive filesystem. **Image JSON** • Each image has an associated JSON structure which describes some basic information about the image such as date created, author, as well as execution/runtime configuration like its entrypoint, default arguments, networking, and volumes. • The JSON structure also references a cryptographic hash of each layer used by the image, and provides history information for those layers. • This JSON is considered to be immutable, because changing it would change the computed ImageID. • Changing it means creating a new derived image, instead of changing the existing image. https://github.com/opencontainers/image-spec/blob/a6af2b480dcfc001ba975f44de53001c873cb0ef/config.md

Claim 1	Accused Instrumentalities
	• **rootfs** *object*, REQUIRED The rootfs key references the layer content addresses used by the image. This makes the image config hash depend on the filesystem hash. ◦ **type** *string*, REQUIRED MUST be set to `layers`. Implementations MUST generate an error if they encounter a unknown value while verifying or unpacking an image. ◦ **diff_ids** *array of strings*, REQUIRED An array of layer content hashes (`DiffIDs`), in order from first to last. https://github.com/opencontainers/image-spec/blob/a6af2b480dcfc001ba975f44de53001c873cb0ef/config.md

Claim 2

Claim 2	**Accused Instrumentalities**
2. A method as defined in claim 1, wherein each container has an execution file associated therewith for starting the one or more applications.	IBM practices, through the Accused Instrumentalities, a method as defined in claim 1, wherein each container has an execution file associated therewith for starting the one or more applications. For example, a container image has an associated image configuration comprising information for starting the one or more applications. This can be an Open Containers Initiative image configuration. *See, e.g.*:

Claim 2	Accused Instrumentalities
	Open Container Initiative **Image Format Specification** This specification defines an OCI Image, consisting of an image manifest, an image index (optional), a set of filesystem layers, and a configuration. The goal of this specification is to enable the creation of interoperable tools for building, transporting, and preparing a container image to run. https://github.com/opencontainers/image-spec/blob/a6af2b480dcfc001ba975f44de53001c873cb0ef/spec.md

Claim 2	Accused Instrumentalities
	Overview At a high level the image manifest contains metadata about the contents and dependencies of the image including the content-addressable identity of one or more filesystem layer changeset archives that will be unpacked to make up the final runnable filesystem. The image configuration includes information such as application arguments, environments, etc. The image index is a higher-level manifest which points to a list of manifests and descriptors. Typically, these manifests may provide different implementations of the image, possibly varying by platform or other attributes.  https://github.com/opencontainers/image-spec/blob/a6af2b480dcfc001ba975f44de53001c873cb0ef/spec.md

Claim 2	Accused Instrumentalities
	OCI Image Configuration An OCI *Image* is an ordered collection of root filesystem changes and the corresponding execution parameters for use within a container runtime. This specification outlines the JSON format describing images for use with a container runtime and execution tool and its relationship to filesystem changesets, described in Layers. This section defines the `application/vnd.oci.image.config.v1+json` media type. https://github.com/opencontainers/image-spec/blob/a6af2b480dcfc001ba975f44de53001c873cb0ef/config.md

Claim 2	Accused Instrumentalities
	• **config** *object*, OPTIONAL The execution parameters which SHOULD be used as a base when running a container using the image. This field can be `null`, in which case any execution parameters should be specified at creation of the container. ◦ **Env** *array of strings*, OPTIONAL Entries are in the format of `VARNAME=VARVALUE`. These values act as defaults and are merged with any specified when creating a container. ◦ **Entrypoint** *array of strings*, OPTIONAL A list of arguments to use as the command to execute when the container starts. These values act as defaults and may be replaced by an entrypoint specified when creating a container. ◦ **Cmd** *array of strings*, OPTIONAL Default arguments to the entrypoint of the container. These values act as defaults and may be replaced by any specified when creating a container. If an `Entrypoint` value is not specified, then the first entry of the `Cmd` array SHOULD be interpreted as the executable to run. https://github.com/opencontainers/image-spec/blob/a6af2b480dcfc001ba975f44de53001c873cb0ef/config.md

<u>Claim 6</u>

Claim 6	Accused Instrumentalities
6. A method as defined in claim 2, comprising the step of assigning a unique associated identity to each of a plurality of the containers, wherein the identity includes at least one of IP address, host name, and MAC address.	IBM practices, through the Accused Instrumentalities, a method as defined in claim 2, comprising the step of assigning a unique associated identity to each of a plurality of the containers, wherein the identity includes at least one of IP address, host name, and MAC address. For example, Kubernetes containers have an associated hostname, which in the case of a single-container Pod is the unique identity of that container. For another example, Kubernetes pods have an associated hostname, which is unique. For another example, a networked Kubernetes pod has an assigned IPv4 and/or IPv6 address. For another example, a Docker container has an IP address and a hostname. *See, e.g.*: **Container information** The *hostname* of a Container is the name of the Pod in which the Container is running. It is available through the `hostname` command or the `gethostname` function call in libc. The Pod name and namespace are available as environment variables through the downward API. User defined environment variables from the Pod definition are also available to the Container, as are any environment variables specified statically in the container image. https://kubernetes.io/docs/concepts/containers/container-environment/

Claim 6	Accused Instrumentalities
	IP address and hostname By default, the container gets an IP address for every Docker network it attaches to. A container receives an IP address out of the IP subnet of the network. The Docker daemon performs dynamic subnetting and IP address allocation for containers. Each network also has a default subnet mask and gateway. You can connect a running container to multiple networks, either by passing the `--network` flag multiple times when creating the container, or using the `docker network connect` command for already running containers. In both cases, you can use the `--ip` or `--ip6` flags to specify the container's IP address on that particular network. In the same way, a container's hostname defaults to be the container's ID in Docker. You can override the hostname using `--hostname`. When connecting to an existing network using `docker network connect`, you can use the `--alias` flag to specify an additional network alias for the container on that network. https://docs.docker.com/network/

Claim 9

Claim 9	Accused Instrumentalities
9. A method as defined in claim 2, wherein server information related to hardware resource usage including at least one of CPU memory, network bandwidth, and disk allocation is associated with at least some of the containers prior to the applications within the containers being executed.	IBM practices, through the Accused Instrumentalities, a method as defined in claim 2, wherein server information related to hardware resource usage including at least one of CPU memory, network bandwidth, and disk allocation is associated with at least some of the containers prior to the applications within the containers being executed. For example, Kubernetes tracks and limits resource usage, including CPU and memory resources. For another example, Docker tracks and limits resource usage, including CPU and memory resources. *See, e.g.*:

	Resource Management for Pods and Containers When you specify a Pod, you can optionally specify how much of each resource a container needs. The most common resources to specify are CPU and memory (RAM); there are others. When you specify the resource *request* for containers in a Pod, the kube-scheduler uses this information to decide which node to place the Pod on. When you specify a resource *limit* for a container, the kubelet enforces those limits so that the running container is not allowed to use more of that resource than the limit you set. The kubelet also reserves at least the *request* amount of that system resource specifically for that container to use. Requests and limits If the node where a Pod is running has enough of a resource available, it's possible (and allowed) for a container to use more resource than its `request` for that resource specifies. However, a container is not allowed to use more than its resource `limit`. For example, if you set a `memory` request of 256 MiB for a container, and that container is in a Pod scheduled to a Node with 8GiB of memory and no other Pods, then the container can try to use more RAM. If you set a `memory` limit of 4GiB for that container, the kubelet (and container runtime) enforce the limit. The runtime prevents the container from using more than the configured resource limit. For example: when a process in the container tries to consume more than

Claim 9	Accused Instrumentalities
	the allowed amount of memory, the system kernel terminates the process that attempted the allocation, with an out of memory (OOM) error. Limits can be implemented either reactively (the system intervenes once it sees a violation) or by enforcement (the system prevents the container from ever exceeding the limit). Different runtimes can have different ways to implement the same restrictions. https://kubernetes.io/docs/concepts/configuration/manage-resources-containers/ **Runtime options with Memory, CPUs, and GPUs** By default, a container has no resource constraints and can use as much of a given resource as the host's kernel scheduler allows. Docker provides ways to control how much memory, or CPU a container can use, setting runtime configuration flags of the `docker run` command. This section provides details on when you should set such limits and the possible implications of setting them. **Limit a container's access to memory** Docker can enforce hard or soft memory limits. • Hard limits lets the container use no more than a fixed amount of memory. • Soft limits lets the container use as much memory as it needs unless certain conditions are met, such as when the kernel detects low memory or contention on the host machine. https://docs.docker.com/config/containers/resource_constraints/

Claim 10

Claim 10	Accused Instrumentalities
10. A method as defined in claim 2, wherein in operation when an application residing within a container is executed, said application has no access to system files or applications in other containers or to system files within the operating system during execution thereof.	IBM practices, through the Accused Instrumentalities, a method as defined in claim 2, wherein in operation when an application residing within a container is executed, said application has no access to system files or applications in other containers or to system files within the operating system during execution thereof. *See, e.g.*: Containers are made possible by process isolation and virtualization capabilities built into the Linux kernel. These capabilities—such as *control groups* (Cgroups) for allocating resources among processes, and *namespaces* for restricting a processes access or visibility into other resources or areas of the system—enable multiple application components to share the resources of a single instance of the host operating system in much the same way that a hypervisor enables multiple virtual machines (VMs) to share the CPU, memory and other resources of a single hardware server. https://www.ibm.com/topics/docker **Fault isolation:** Each containerized application is isolated and operates independently of others. The failure of one container does not affect the continued operation of any other containers. Development teams can identify and correct any technical issues within one container without any downtime in other containers. Also, the container engine can leverage any OS security isolation techniques—such as SELinux access control—to isolate faults within containers. https://www.ibm.com/topics/containerization

~~Claim 31~~

~~Claim 31~~	~~Accused Instrumentalities~~
~~[31pre] A computing system for performing a plurality of tasks each comprising a plurality of processes comprising:~~	~~To the extent the preamble is construed as a limitation, each Accused Instrumentality is or comprises a computing system for performing a plurality of tasks each comprising a plurality of processes.~~ ~~*See* claim limitations below. *See also* analysis and evidence for [1pre] above.~~
~~[31a] a system having a plurality of secure containers of associated files accessible to, and for execution on, one or more servers, each container being mutually exclusive of the other, such that read/write files within a container cannot be shared with other containers, each container of files is said to have its own unique identity associated therewith, said identity comprising at least one of an IP address, a host name, and a Mac_address~~	~~Each Accused Instrumentality comprises a system having a plurality of secure containers of associated files accessible to, and for execution on, one or more servers, each container being mutually exclusive of the other, such that read/write files within a container cannot be shared with other containers, each container of files is said to have its own unique identity associated therewith, said identity comprising at least one of an IP address, a host name, and a Mac_address.~~ ~~*See* analysis and evidence for [1pre], limitations [1a] and [1f], and claim 6 above.~~

~~Claim 31~~	~~Accused Instrumentalities~~
~~[31b] wherein, the plurality of files within each of the plurality of containers comprise one or more application programs including one or more processes, and associated system files for use in executing the one or more processes wherein the associated system files are files that are copies of files or modified copies of files that remain as part of the operating system, each container having its own execution file associated therewith for starting one or more applications, in operation, each container utilizing a kernel resident on the server and wherein each container exclusively uses a kernel in an underlying operation system in which it is running and is absent its own kernel; and,~~	~~Each Accused Instrumentality comprises a system wherein the plurality of files within each of the plurality of containers comprise one or more application programs including one or more processes, and associated system files for use in executing the one or more processes wherein the associated system files are files that are copies of files or modified copies of files that remain as part of the operating system, each container having its own execution file associated therewith for starting one or more applications, in operation, each container utilizing a kernel resident on the server and wherein each container exclusively uses a kernel in an underlying operation system in which it is running and is absent its own kernel.~~ ~~*See* analysis and evidence for [1pre], limitations [1a], [1c], [1d], [1e], and [1f], and claim 2 above.~~

~~[31c] a run time module for monitoring system calls from applications associated with one or more containers and for providing control of the one or more applications.~~	~~Each Accused Instrumentality comprises a run time module for monitoring system calls from applications associated with one or more containers and for providing control of the one or more applications.~~ ~~For example, IBM Cloud Kubernetes Service includes the containerd runtime module or another container runtime. For another example, Kubernetes uses the Linux kernel's seccomp mode to monitor and control system calls made from a container.~~ ~~*See, e.g.*:~~ Security Bulletin: IBM Cloud Kubernetes Service is affected by a containerd security vulnerability (CVE-2024-21626) **Security Bulletin** **Summary** IBM Cloud Kubernetes Service is affected by a security vulnerability found in the runc component shipped with containerd where an attacker could gain unauthorized access to the host filesystem (CVE-2024-21626). ~~https://www.ibm.com/support/pages/security-bulletin-ibm-cloud-kubernetes-service-affected-containerd-security-vulnerability-cve-2024-21626~~

	## containerd Adopters A non-exhaustive list of containerd adopters is provided below. ***Docker/Moby engine*** - Containerd began life prior to its CNCF adoption as a lower-layer runtime manager for `runc` processes below the Docker engine. Continuing today, containerd has extremely broad production usage as a component of the Docker engine stack. Note that this includes any use of the open source Moby engine project; including the Balena project listed below. ***IBM Cloud Kubernetes Service (IKS)*** - offers containerd as the CRI runtime for v1.11 and higher versions. ***IBM Cloud Private (ICP)*** - IBM's on-premises cloud offering has containerd as a "tech preview" CRI runtime for the Kubernetes offered within this product for the past two releases, and plans to fully migrate to containerd in a future release. ~~**https://github.com/moby/containerd/blob/docker/20.10/ADOPTERS.md**~~

	Container Runtimes **Note:** Dockershim has been removed from the Kubernetes project as of release 1.24. Read the Dockershim Removal FAQ for further details. ~~You need to install a container runtime into each node in the cluster~~ so that Pods can run there. This page outlines what is involved and describes related tasks for setting up nodes. Kubernetes 1.30 requires that you use a runtime that conforms with the Container Runtime Interface (CRI). See CRI version support for more information. ~~https://kubernetes.io/docs/setup/production-environment/container-runtimes/~~

~~Claim 31~~	~~Accused Instrumentalities~~
	Restrict a Container's Syscalls with seccomp ⓘ **FEATURE STATE:** `Kubernetes v1.19 [stable]` Seccomp stands for secure computing mode and has been a feature of the Linux kernel since version 2.6.12. It can be used to sandbox the privileges of a process, restricting the calls it is able to make from userspace into the kernel. Kubernetes lets you automatically apply seccomp profiles loaded onto a node to your Pods and containers. Identifying the privileges required for your workloads can be difficult. In this tutorial, you will go through how to load seccomp profiles into a local Kubernetes cluster, how to apply them to a Pod, and how you can begin to craft profiles that give only the necessary privileges to your container processes. ~~https://kubernetes.io/docs/tutorials/security/seccomp/~~

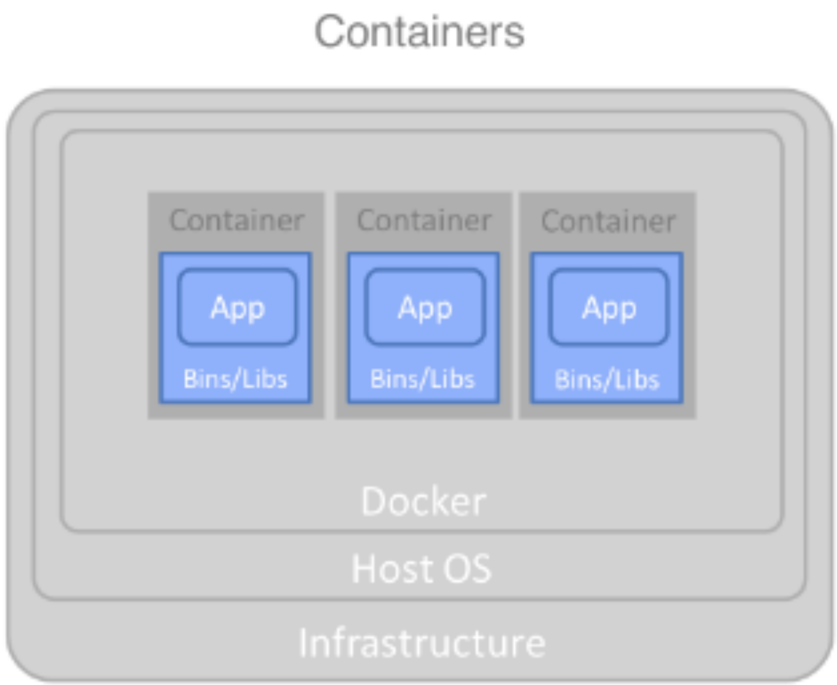
U.S. Patent No. 7,784,058 ("'058 Patent")

Accused Instrumentalities: IBM products and services using user mode critical system elements as shared libraries, including without limitation IBM Cloud Kubernetes Service (IKS), IBM Cloud Private (ICP), and IBM Hybrid Cloud mesh,, and all versions and variations thereof since the issuance of the asserted patent.

Each Accused Instrumentality infringes the claims in substantially the same way, and the evidence shown in this chart is similarly applicable to each Accused Instrumentality. Each claim limitation is literally infringed by each Accused Instrumentality. However, to the extent any claim limitation is not met literally, it is nonetheless met under the doctrine of equivalents because the differences between the claim limitation and each Accused Instrumentality would be insubstantial, and each Accused Instrumentality performs substantially the same function, in substantially the same way, to achieve the same result as the claimed invention. Notably, Defendant has not yet articulated which, if any, particular claim limitations it believes are not met by the Accused Instrumentalities.

Claim 1

Claim 1	Accused Instrumentalities
[1pre] 1. A computing system for executing a plurality of software applications comprising:	To the extent the preamble is limiting, each Accused Instrumentality comprises or constitutes a computing system for executing a plurality of software applications as claimed. *See* claim limitations below. *See also, e.g.*: IBM Cloud® Kubernetes Service provides a fully managed container service for Docker (OCI) containers, so clients can deploy containerized apps onto a pool of compute hosts and subsequently manage those containers. Containers are automatically scheduled and placed onto available compute hosts based on your requirements and availability in the cluster. https://www.ibm.com/products/kubernetes-service With IBM Cloud Kubernetes Service, you can deploy Docker containers into pods that run on your worker nodes. The worker nodes come with a set of add-on pods to help you manage your containers. Install more add-ons through Helm, a Kubernetes package manager. These add-ons can extend your apps with dashboards, logging, IBM Cloud and IBM Watson® services and more. https://www.ibm.com/products/kubernetes-service

Claim 1	Accused Instrumentalities
	 https://developer.ibm.com/articles/true-benefits-of-moving-to-containers-1/
[1a] a) a processor;	Each Accused Instrumentality comprises a processor. *See, e.g.*:

Claim 1	Accused Instrumentalities
	Containers are executable units of software in which application code is packaged along with its libraries and dependencies, in common ways so that the code can be run anywhere—whether it be on desktop, traditional IT or the cloud. To do this, containers take advantage of a form of operating system (OS) virtualization in which features of the OS kernel (e.g. Linux namespaces and cgroups, Windows silos and job objects) can be leveraged to isolate processes and control the amount of CPU, memory and disk that those processes can access. Containers are small, fast and portable because unlike a virtual machine, containers do not need to include a guest OS in every instance and can instead simply leverage the features and resources of the host OS. https://www.ibm.com/topics/containers Containers use a form of operating system (OS) virtualization. Put simply, they leverage features of the host operating system to isolate processes and control the processes' access to CPUs, memory and desk space. https://www.ibm.com/blog/containers-vs-vms/

Claim 1	Accused Instrumentalities
[1b] b) an operating system having an operating system kernel having OS critical system elements (OSCSEs) for running in kernel mode using said processor; and,	Each Accused Instrumentality comprises an operating system having an operating system kernel having OS critical system elements (OSCSEs) for running in kernel mode using said processor. *See, e.g.*: Containerization is the packaging of software code with just the operating system (OS) libraries and dependencies required to run the code to create a single lightweight executable—called a container—that runs consistently on any infrastructure. More portable and resource-efficient than virtual machines (VMs), containers have become the de facto compute units of modern cloud-native applications. Containerization allows developers to create and deploy applications faster and more securely. With traditional methods, code is developed in a specific computing environment which, when transferred to a new location, often results in bugs and errors. For example, when a developer transfers code from a desktop computer to a VM or from a Linux to a Windows operating system. Containerization eliminates this problem by bundling the application code together with the related configuration files, libraries, and dependencies required for it to run. This single package of software or "container" is abstracted away from the host operating system, and hence, it stands alone and becomes portable—able to run across any platform or cloud, free of issues. https://www.ibm.com/topics/containerization **Kernel mode** Kernel mode refers to the processor mode that enables software to have full and unrestricted access to the system and its resources. The OS kernel and kernel drivers, such as the file system driver, are loaded into protected memory space and operate in this highly privileged kernel mode. https://www.techtarget.com/searchdatacenter/definition/kernel

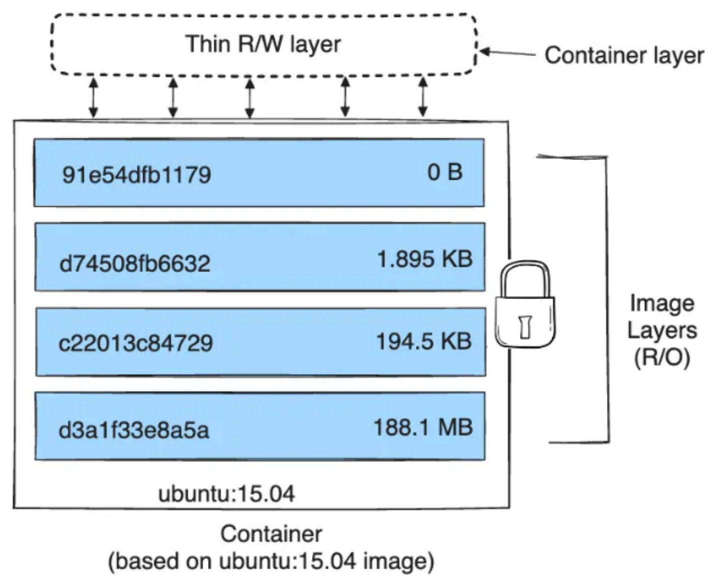
Claim 1	Accused Instrumentalities
	The **GNU C Library**, commonly known as **glibc**, is the GNU Project implementation of the C standard library. It is a wrapper around the system calls of the Linux kernel for application use. Despite its name, it now also directly supports C++ (and, indirectly, other programming languages). It was started in the 1980s by the Free Software Foundation (FSF) for the GNU operating system. https://en.wikipedia.org/wiki/Glibc
[1c] c) a shared library having shared library critical system elements (SLCSEs) stored therein for use by the plurality of software applications in user mode and	Each Accused Instrumentality comprises a shared library having shared library critical system elements (SLCSEs) stored therein for use by the plurality of software applications in user mode. *See, e.g.*: A Docker image is the basis for every container that you create with IBM Cloud® Kubernetes Service. An image is created from a Dockerfile, which is a file that contains instructions to build the image. A Dockerfile might reference build artifacts in its instructions that are stored separately, such as an app, the app's configuration, and its dependencies. https://cloud.ibm.com/docs/containers?topic=containers-images

Claim 1	Accused Instrumentalities
	Docker base image / **Supported versions** / **Source of security notices** Alpine — All stable versions with vendor security support. — Alpine SecDB database. Debian — All stable versions with vendor security support. CVEs on binary packages that are associated with the Debian source package `linux`, such as `linux-libc-dev`, are not reported. Most of these binary packages are kernel and kernel modules, which are not run in container images. — Debian Security Bug Tracker. GoogleContainerTools distroless — All stable versions with vendor security support. — GoogleContainerTools distroless Red Hat® Enterprise Linux® (RHEL) — RHEL/UBI 7, RHEL/UBI 8, and RHEL/UBI 9 — Red Hat Security Data API. Ubuntu — All stable versions with vendor security support. — Ubuntu CVE Tracker. https://cloud.ibm.com/docs/Registry?topic=Registry-va_index&interface=ui

Claim 1	Accused Instrumentalities
	# About storage drivers To use storage drivers effectively, it's important to know how Docker builds and stores images, and how these images are used by containers. You can use this information to make informed choices about the best way to persist data from your applications and avoid performance problems along the way. ## Storage drivers versus Docker volumes Docker uses storage drivers to store image layers, and to store data in the writable layer of a container. The container's writable layer doesn't persist after the container is deleted, but is suitable for storing ephemeral data that is generated at runtime. Storage drivers are optimized for space efficiency, but (depending on the storage driver) write speeds are lower than native file system performance, especially for storage drivers that use a copy-on-write filesystem. Write-intensive applications, such as database storage, are impacted by a performance overhead, particularly if pre-existing data exists in the read-only layer. Use Docker volumes for write-intensive data, data that must persist beyond the container's lifespan, and data that must be shared between containers. Refer to the volumes section to learn how to use volumes to persist data and improve performance. https://docs.docker.com/storage/storagedriver/

Claim 1	Accused Instrumentalities

	Images and layers
	
	A Docker image is built up from a series of layers. Each layer represents an instruction in the image's Dockerfile. Each layer except the very last one is read-only. Consider the following Dockerfile:
	
	`# syntax=docker/dockerfile:1`
	
	`FROM ubuntu:22.04`
	`LABEL org.opencontainers.image.authors="org@example.com"`
	`COPY . /app`
	`RUN make /app`
	`RUN rm -r $HOME/.cache`
	`CMD python /app/app.py`
	
	This Dockerfile contains four commands. Commands that modify the filesystem create a layer. The `FROM` statement starts out by creating a layer from the `ubuntu:22.04` image. The `LABEL` command only modifies the image's metadata, and doesn't produce a new layer. The `COPY` command adds some files from your Docker client's current directory. The first `RUN` command builds your application using the `make` command, and writes the result to a new layer. The second `RUN` command removes a cache directory, and writes the result to a new layer. Finally, the `CMD` instruction specifies what command to run within the container, which only modifies the image's metadata, which doesn't produce an image layer.
	
	https://docs.docker.com/storage/storagedriver/

	Each layer is only a set of differences from the layer before it. Note that both *adding*, and *removing* files will result in a new layer. In the example above, the `$HOME/.cache` directory is removed, but will still be available in the previous layer and add up to the image's total size. Refer to the Best practices for writing Dockerfiles and use multi-stage builds sections to learn how to optimize your Dockerfiles for efficient images. The layers are stacked on top of each other. When you create a new container, you add a new writable layer on top of the underlying layers. This layer is often called the "container layer". All changes made to the running container, such as writing new files, modifying existing files, and deleting files, are written to this thin writable container layer. The diagram below shows a container based on an `ubuntu:15.04` image.  https://docs.docker.com/storage/storagedriver/

Claim 1	Accused Instrumentalities
	Volumes Volumes are the preferred mechanism for persisting data generated by and used by Docker containers. While bind mounts are dependent on the directory structure and OS of the host machine, volumes are completely managed by Docker. Volumes have several advantages over bind mounts: https://kubernetes.io/docs/concepts/storage/volumes/ **Container environment** The Kubernetes Container environment provides several important resources to Containers: • A filesystem, which is a combination of an image and one or more volumes. • Information about the Container itself. • Information about other objects in the cluster. https://kubernetes.io/docs/concepts/containers/container-environment/

Claim 1	Accused Instrumentalities
	Images A container image represents binary data that encapsulates an application and all its software dependencies. Container images are executable software bundles that can run standalone and that make very well defined assumptions about their runtime environment. You typically create a container image of your application and push it to a registry before referring to it in a Pod. https://kubernetes.io/docs/concepts/containers/images/ **Volumes** On-disk files in a container are ephemeral, which presents some problems for non-trivial applications when running in containers. One problem occurs when a container crashes or is stopped. Container state is not saved so all of the files that were created or modified during the lifetime of the container are lost. During a crash, kubelet restarts the container with a clean state. Another problem occurs when multiple containers are running in a `Pod` and need to share files. It can be challenging to setup and access a shared filesystem across all of the containers. The Kubernetes volume abstraction solves both of these problems. Familiarity with Pods is suggested. https://kubernetes.io/docs/concepts/storage/volumes/

Claim 1	Accused Instrumentalities
	# Open Container Initiative ## Image Format Specification This specification defines an OCI Image, consisting of an image manifest, an image index (optional), a set of filesystem layers, and a configuration. The goal of this specification is to enable the creation of interoperable tools for building, transporting, and preparing a container image to run. https://github.com/opencontainers/image-spec/blob/a6af2b480dcfc001ba975f44de53001c873cb0ef/spec.md

<table>
<tr><th>Claim 1</th><th>Accused Instrumentalities</th></tr>
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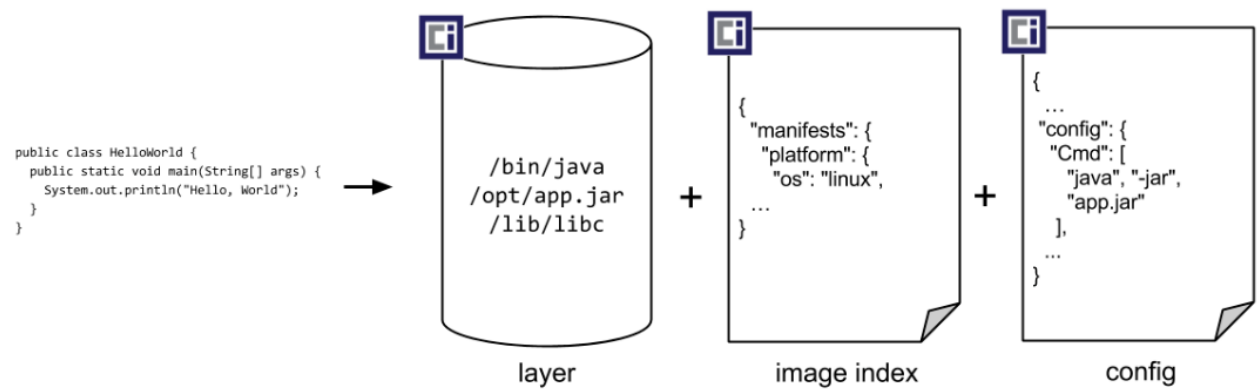
Overview

At a high level the image manifest contains metadata about the contents and dependencies of the image including the content-addressable identity of one or more filesystem layer changeset archives that will be unpacked to make up the final runnable filesystem. The image configuration includes information such as application arguments, environments, etc. The image index is a higher-level manifest which points to a list of manifests and descriptors. Typically, these manifests may provide different implementations of the image, possibly varying by platform or other attributes.



https://github.com/opencontainers/image-spec/blob/a6af2b480dcfc001ba975f44de53001c873cb0ef/spec.md

</td></tr>
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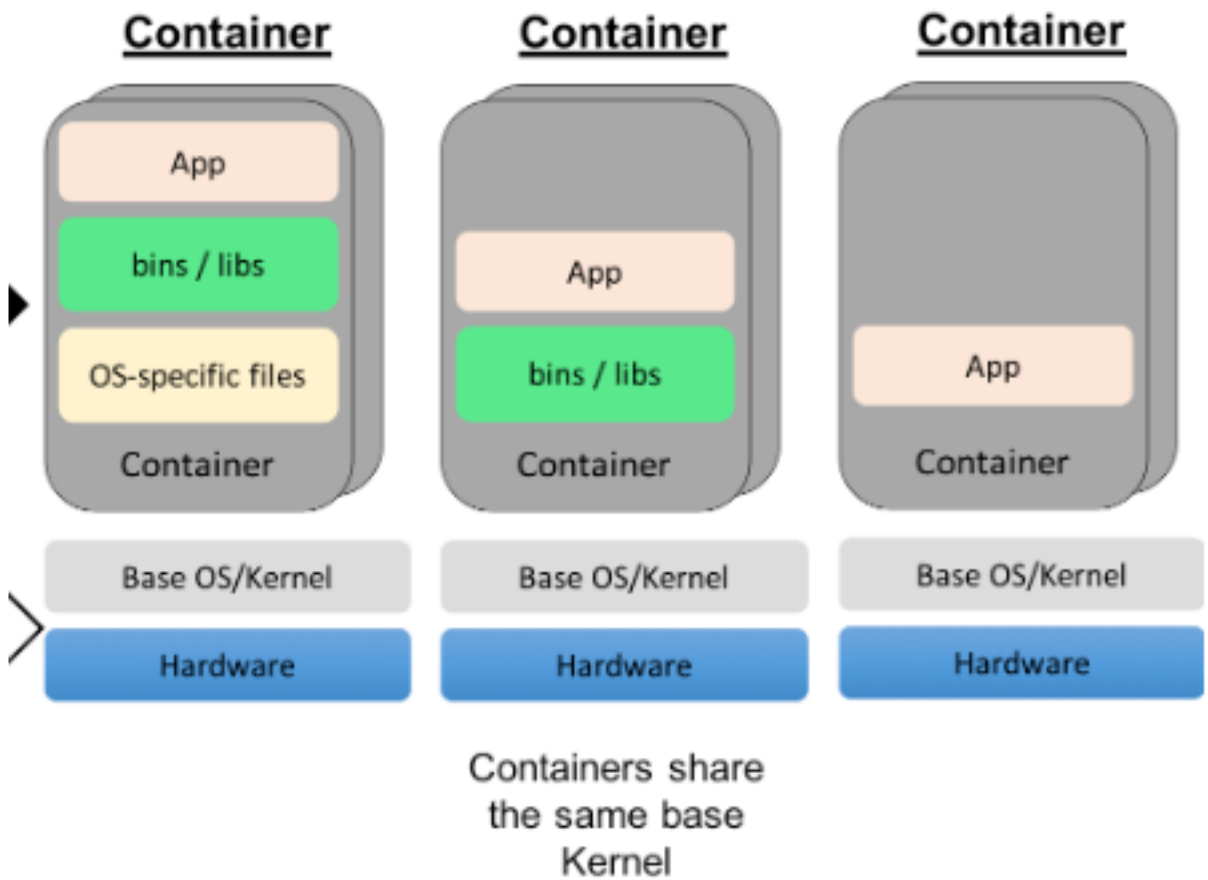
Claim 1	Accused Instrumentalities
	# OCI Image Configuration An OCI *Image* is an ordered collection of root filesystem changes and the corresponding execution parameters for use within a container runtime. This specification outlines the JSON format describing images for use with a container runtime and execution tool and its relationship to filesystem changesets, described in Layers. This section defines the `application/vnd.oci.image.config.v1+json` media type. https://github.com/opencontainers/image-spec/blob/a6af2b480dcfc001ba975f44de53001c873cb0ef/config.md

Claim 1	Accused Instrumentalities
	Layer • Image filesystems are composed of *layers*. • Each layer represents a set of filesystem changes in a tar-based layer format, recording files to be added, changed, or deleted relative to its parent layer. • Layers do not have configuration metadata such as environment variables or default arguments - these are properties of the image as a whole rather than any particular layer. • Using a layer-based or union filesystem such as AUFS, or by computing the diff from filesystem snapshots, the filesystem changeset can be used to present a series of image layers as if they were one cohesive filesystem. **Image JSON** • Each image has an associated JSON structure which describes some basic information about the image such as date created, author, as well as execution/runtime configuration like its entrypoint, default arguments, networking, and volumes. • The JSON structure also references a cryptographic hash of each layer used by the image, and provides history information for those layers. • This JSON is considered to be immutable, because changing it would change the computed ImageID. • Changing it means creating a new derived image, instead of changing the existing image. https://github.com/opencontainers/image-spec/blob/a6af2b480dcfc001ba975f44de53001c873cb0ef/config.md

Claim 1	Accused Instrumentalities
	Docker images contain executable application source code as well as all the tools, libraries, and dependencies that the application code needs to run as a container. When you run the Docker image, it becomes one instance (or multiple instances) of the container. It's possible to build a Docker image from scratch, but most developers pull them down from common repositories. Multiple Docker images can be created from a single base image, and they'll share the commonalities of their stack. Docker images are made up of layers, and each layer corresponds to a version of the image. Whenever a developer makes changes to the image, a new top layer is created, and this top layer replaces the previous top layer as the current version of the image. Previous layers are saved for rollbacks or to be re-used in other projects. Each time a container is created from a Docker image, yet another new layer called the container layer is created. Changes made to the container—such as the addition or deletion of files—are saved to the container layer only and exist only while the container is running. This iterative image-creation process enables increased overall efficiency since multiple live container instances can run from just a single base image, and when they do so, they leverage a common stack. https://www.ibm.com/topics/docker

Claim 1	Accused Instrumentalities
	 https://ibm.github.io/kube101/

Claim 1	Accused Instrumentalities
	The **GNU C Library**, commonly known as **glibc**, is the GNU Project implementation of the C standard library. It is a wrapper around the system calls of the Linux kernel for application use. Despite its name, it now also directly supports C++ (and, indirectly, other programming languages). It was started in the 1980s by the Free Software Foundation (FSF) for the GNU operating system. https://en.wikipedia.org/wiki/Glibc
[1d] i) wherein some of the SLCSEs stored in the shared library are functional replicas of OSCSEs and are accessible to some of the plurality of software applications and when one of the SLCSEs is accessed by one or more of the plurality of software applications it forms a part of the one or more of the plurality of software applications,	In each Accused Instrumentality, some of the SLCSEs stored in the shared library are functional replicas of OSCSEs and are accessible to some of the plurality of software applications and when one of the SLCSEs is accessed by one or more of the plurality of software applications it forms a part of the one or more of the plurality of software applications. For example, a base image serves as a self-contained unit that encompasses all the necessary components for an application to run, including the application code, runtime environment, system tools, and dependencies (i.e., SLCSEs). The images are based on existing Linux distributions, such as Debian and Ubuntu, including essential system elements (i.e., functional replicas of OSCSEs). Each container image is based on a specific base image, which contains the application code, and dependencies, including system libraries or shared library critical system elements (SLCSEs). When the container runs the image, it creates a runtime instance of that container image. *See, e.g.*: A Docker image is the basis for every container that you create with IBM Cloud® Kubernetes Service. An image is created from a Dockerfile, which is a file that contains instructions to build the image. A Dockerfile might reference build artifacts in its instructions that are stored separately, such as an app, the app's configuration, and its dependencies. https://cloud.ibm.com/docs/containers?topic=containers-images

Claim 1	Accused Instrumentalities
	Docker images contain executable application source code as well as all the tools, libraries, and dependencies that the application code needs to run as a container. When you run the Docker image, it becomes one instance (or multiple instances) of the container. It's possible to build a Docker image from scratch, but most developers pull them down from common repositories. Multiple Docker images can be created from a single base image, and they'll share the commonalities of their stack. Docker images are made up of layers, and each layer corresponds to a version of the image. Whenever a developer makes changes to the image, a new top layer is created, and this top layer replaces the previous top layer as the current version of the image. Previous layers are saved for rollbacks or to be re-used in other projects. Each time a container is created from a Docker image, yet another new layer called the container layer is created. Changes made to the container—such as the addition or deletion of files—are saved to the container layer only and exist only while the container is running. This iterative image-creation process enables increased overall efficiency since multiple live container instances can run from just a single base image, and when they do so, they leverage a common stack. https://www.ibm.com/topics/docker Following software is installed on the Docker containers as part of the Product Master image deployment: – Red Hat Enterprise Linux (RHEL) 7 Universal Base Image (UBI) base Docker image https://www.ibm.com/docs/en/product-master/12.0.0?topic=deployment-installing-product-by-using-docker-images

Claim 1	Accused Instrumentalities
	ubuntu ⬇1B+ · ☆10K+ Updated 15 days ago Ubuntu is a Debian-based Linux operating system based on free software. Linux IBM Z 386 riscv64 x86-64 ARM ARM 64 PowerPC 64 LE debian ⬇1B+ · ☆4.9K Updated 35 minutes ago Debian is a Linux distribution that's composed entirely of free and open-source software. Linux riscv64 x86-64 ARM ARM 64 386 mips64le PowerPC 64 LE IBM Z https://hub.docker.com/search?image_filter=official&type=image&q=

Claim 1	Accused Instrumentalities

Platform	x86_64 / amd64	arm64 / aarch64	arm (32-bit)	ppc64le	s390x
CentOS	✅	✅		✅	
Debian	✅	✅	✅	✅	
Fedora	✅	✅		✅	
Raspberry Pi OS (32-bit)			✅		
RHEL (s390x)					✅
SLES					✅
Ubuntu	✅	✅	✅	✅	✅
Binaries	✅	✅	✅		

https://docs.docker.com/engine/install/

Docker is used to create, run and deploy applications in containers. A Docker image contains application code, libraries, tools, dependencies and other files needed to make an application run. When a user runs an image, it can become one or many instances of a container.

https://www.techtarget.com/searchitoperations/definition/Docker-image

Docker images contain executable application source code as well as all the tools, libraries, and dependencies that the application code needs to run as a container. When you run the Docker image, it becomes one instance (or multiple instances) of the container.

https://www.ibm.com/topics/docker

Claim 1	Accused Instrumentalities
	container — A container is a runtime instance of a docker image. A Docker container consists of • A Docker image • An execution environment • A standard set of instructions https://docs.docker.com/glossary/#image

Claim 1	Accused Instrumentalities
	# About storage drivers To use storage drivers effectively, it's important to know how Docker builds and stores images, and how these images are used by containers. You can use this information to make informed choices about the best way to persist data from your applications and avoid performance problems along the way. ## Storage drivers versus Docker volumes Docker uses storage drivers to store image layers, and to store data in the writable layer of a container. The container's writable layer doesn't persist after the container is deleted, but is suitable for storing ephemeral data that is generated at runtime. Storage drivers are optimized for space efficiency, but (depending on the storage driver) write speeds are lower than native file system performance, especially for storage drivers that use a copy-on-write filesystem. Write-intensive applications, such as database storage, are impacted by a performance overhead, particularly if pre-existing data exists in the read-only layer. Use Docker volumes for write-intensive data, data that must persist beyond the container's lifespan, and data that must be shared between containers. Refer to the volumes section to learn how to use volumes to persist data and improve performance. https://docs.docker.com/storage/storagedriver/

<table>
<tr><th>Claim 1</th><th>Accused Instrumentalities</th></tr>
<tr><td></td><td>

Images and layers

A Docker image is built up from a series of layers. Each layer represents an instruction in the image's Dockerfile. Each layer except the very last one is read-only. Consider the following Dockerfile:

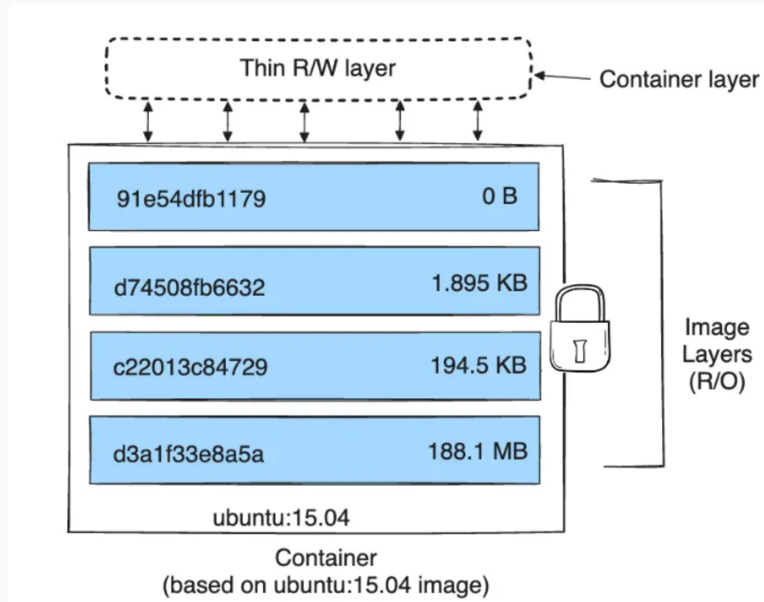
```
# syntax=docker/dockerfile:1

FROM ubuntu:22.04
LABEL org.opencontainers.image.authors="org@example.com"
COPY . /app
RUN make /app
RUN rm -r $HOME/.cache
CMD python /app/app.py
```

This Dockerfile contains four commands. Commands that modify the filesystem create a layer. The `FROM` statement starts out by creating a layer from the `ubuntu:22.04` image. The `LABEL` command only modifies the image's metadata, and doesn't produce a new layer. The `COPY` command adds some files from your Docker client's current directory. The first `RUN` command builds your application using the `make` command, and writes the result to a new layer. The second `RUN` command removes a cache directory, and writes the result to a new layer. Finally, the `CMD` instruction specifies what command to run within the container, which only modifies the image's metadata, which doesn't produce an image layer.

https://docs.docker.com/storage/storagedriver/

</td></tr>
</table>

	Each layer is only a set of differences from the layer before it. Note that both *adding*, and *removing* files will result in a new layer. In the example above, the `$HOME/.cache` directory is removed, but will still be available in the previous layer and add up to the image's total size. Refer to the Best practices for writing Dockerfiles and use multi-stage builds sections to learn how to optimize your Dockerfiles for efficient images. The layers are stacked on top of each other. When you create a new container, you add a new writable layer on top of the underlying layers. This layer is often called the "container layer". All changes made to the running container, such as writing new files, modifying existing files, and deleting files, are written to this thin writable container layer. The diagram below shows a container based on an `ubuntu:15.04` image.  https://docs.docker.com/storage/storagedriver/

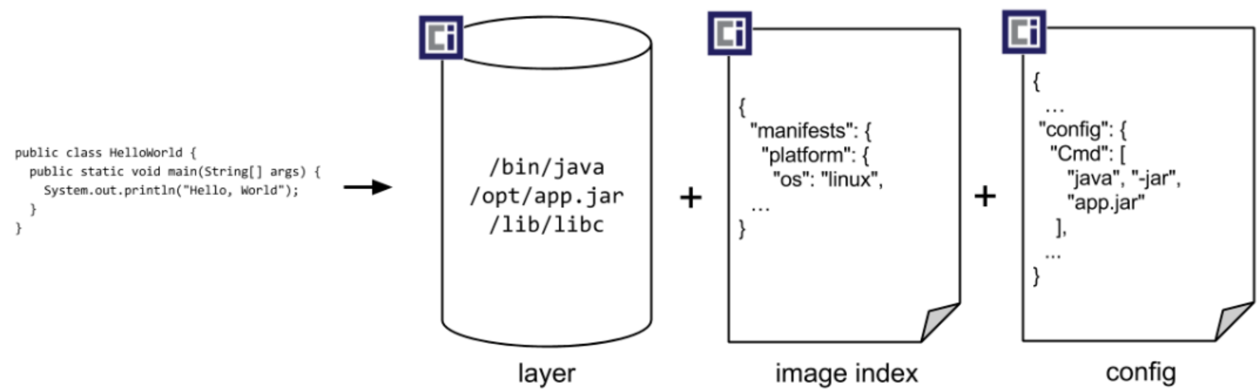
<table>
<tr><th>Claim 1</th><th>Accused Instrumentalities</th></tr>
<tr><td></td><td>
<h1>Volumes</h1>
Volumes are the preferred mechanism for persisting data generated by and used by Docker containers. While bind mounts are dependent on the directory structure and OS of the host machine, volumes are completely managed by Docker. Volumes have several advantages over bind mounts:
https://kubernetes.io/docs/concepts/storage/volumes/
<h2>Container environment</h2>
The Kubernetes Container environment provides several important resources to Containers:

A filesystem, which is a combination of an image and one or more volumes.
Information about the Container itself.
Information about other objects in the cluster.

https://kubernetes.io/docs/concepts/containers/container-environment/
</td></tr>
</table>

Claim 1	Accused Instrumentalities
	Images A container image represents binary data that encapsulates an application and all its software dependencies. Container images are executable software bundles that can run standalone and that make very well defined assumptions about their runtime environment. You typically create a container image of your application and push it to a registry before referring to it in a Pod. https://kubernetes.io/docs/concepts/containers/images/ **Volumes** On-disk files in a container are ephemeral, which presents some problems for non-trivial applications when running in containers. One problem occurs when a container crashes or is stopped. Container state is not saved so all of the files that were created or modified during the lifetime of the container are lost. During a crash, kubelet restarts the container with a clean state. Another problem occurs when multiple containers are running in a `Pod` and need to share files. It can be challenging to setup and access a shared filesystem across all of the containers. The Kubernetes volume abstraction solves both of these problems. Familiarity with Pods is suggested. https://kubernetes.io/docs/concepts/storage/volumes/

Claim 1	Accused Instrumentalities
	Open Container Initiative **Image Format Specification** This specification defines an OCI Image, consisting of an image manifest, an image index (optional), a set of filesystem layers, and a configuration. The goal of this specification is to enable the creation of interoperable tools for building, transporting, and preparing a container image to run. https://github.com/opencontainers/image-spec/blob/a6af2b480dcfc001ba975f44de53001c873cb0ef/spec.md

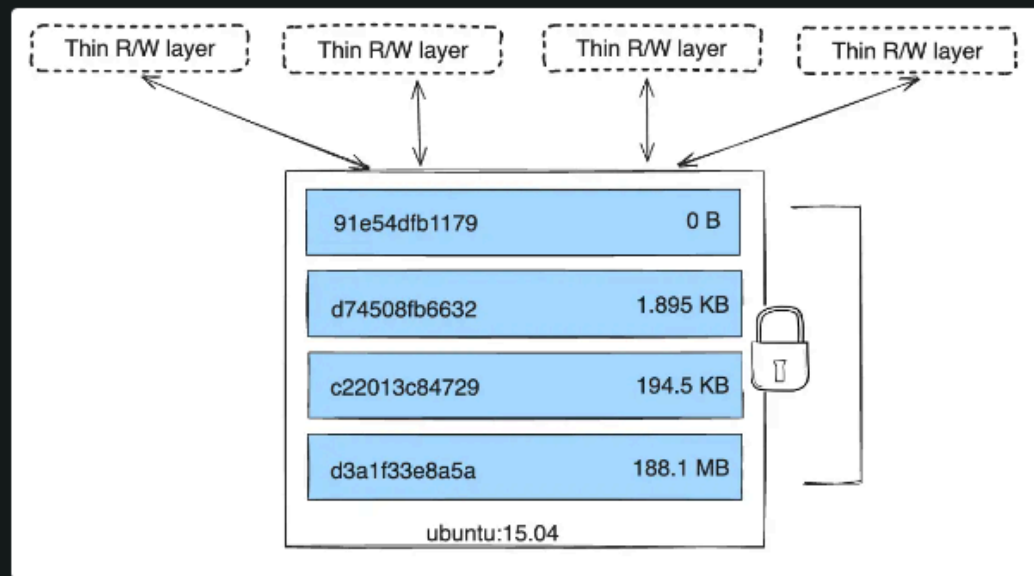
Claim 1	Accused Instrumentalities
	Overview At a high level the image manifest contains metadata about the contents and dependencies of the image including the content-addressable identity of one or more filesystem layer changeset archives that will be unpacked to make up the final runnable filesystem. The image configuration includes information such as application arguments, environments, etc. The image index is a higher-level manifest which points to a list of manifests and descriptors. Typically, these manifests may provide different implementations of the image, possibly varying by platform or other attributes.  https://github.com/opencontainers/image-spec/blob/a6af2b480dcfc001ba975f44de53001c873cb0ef/spec.md

Claim 1	Accused Instrumentalities
	OCI Image Configuration An OCI *Image* is an ordered collection of root filesystem changes and the corresponding execution parameters for use within a container runtime. This specification outlines the JSON format describing images for use with a container runtime and execution tool and its relationship to filesystem changesets, described in Layers. This section defines the `application/vnd.oci.image.config.v1+json` media type. https://github.com/opencontainers/image-spec/blob/a6af2b480dcfc001ba975f44de53001c873cb0ef/config.md

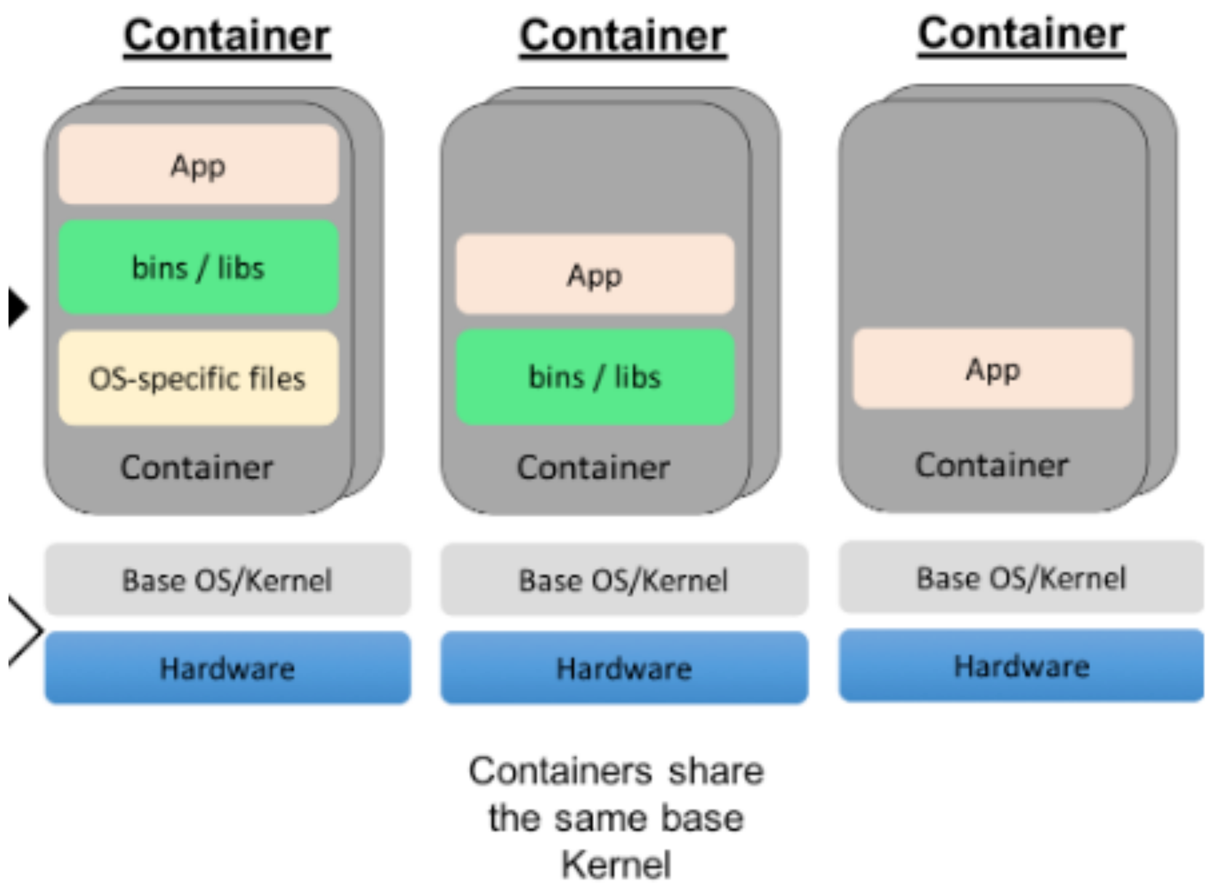
Claim 1	Accused Instrumentalities
	Layer • Image filesystems are composed of *layers*. • Each layer represents a set of filesystem changes in a tar-based layer format, recording files to be added, changed, or deleted relative to its parent layer. • Layers do not have configuration metadata such as environment variables or default arguments - these are properties of the image as a whole rather than any particular layer. • Using a layer-based or union filesystem such as AUFS, or by computing the diff from filesystem snapshots, the filesystem changeset can be used to present a series of image layers as if they were one cohesive filesystem. **Image JSON** • Each image has an associated JSON structure which describes some basic information about the image such as date created, author, as well as execution/runtime configuration like its entrypoint, default arguments, networking, and volumes. • The JSON structure also references a cryptographic hash of each layer used by the image, and provides history information for those layers. • This JSON is considered to be immutable, because changing it would change the computed ImageID. • Changing it means creating a new derived image, instead of changing the existing image. https://github.com/opencontainers/image-spec/blob/a6af2b480dcfc001ba975f44de53001c873cb0ef/config.md

Claim 1	Accused Instrumentalities
[1e] ii) wherein an instance of a SLCSE provided to at least a first of the plurality of software applications from the shared library is run in a context of said at least first of the plurality of software applications without being shared with other of the plurality of software applications and where at least a second of the plurality of software applications running under the operating system have use of a unique instance of a corresponding critical system element for performing same function, and	In each Accused Instrumentality, an instance of a SLCSE provided to at least a first of the plurality of software applications from the shared library is run in a context of said at least first of the plurality of software applications without being shared with other of the plurality of software applications and where at least a second of the plurality of software applications running under the operating system have use of a unique instance of a corresponding critical system element for performing same function. When a Docker or Kubernetes image is used to create a container, it creates a separate and isolated instance of a runtime environment which is independent of other containers running on the same host. Each container has its own instance of base images and its own data. The containers run in isolation, ensuring that the SLCSEs stored in the shared library are accessible to the software applications running in their respective containers. The image includes essential system files, libraries, and dependencies required to run the software application within the container. The containers can share common dependencies and components using layered images. This means that multiple containers utilize the same base image to create an instance. When an instance of SLCSE is provided from the base image (i.e., from the shared library) to an individual container including application software, it operates in isolation and runs its own instance of the software application without sharing resources or critical system elements with other containers. This ensures that each container has its own isolated context. Docker or Kubernetes containers can share common dependencies and components using layered images. This means that multiple containers can utilize the same base image. Therefore, each container, containing the application software running under the operating system, utilizes a unique instance of the corresponding critical system element to execute the respective application software for performing a same or a different function. *See, e.g.*:

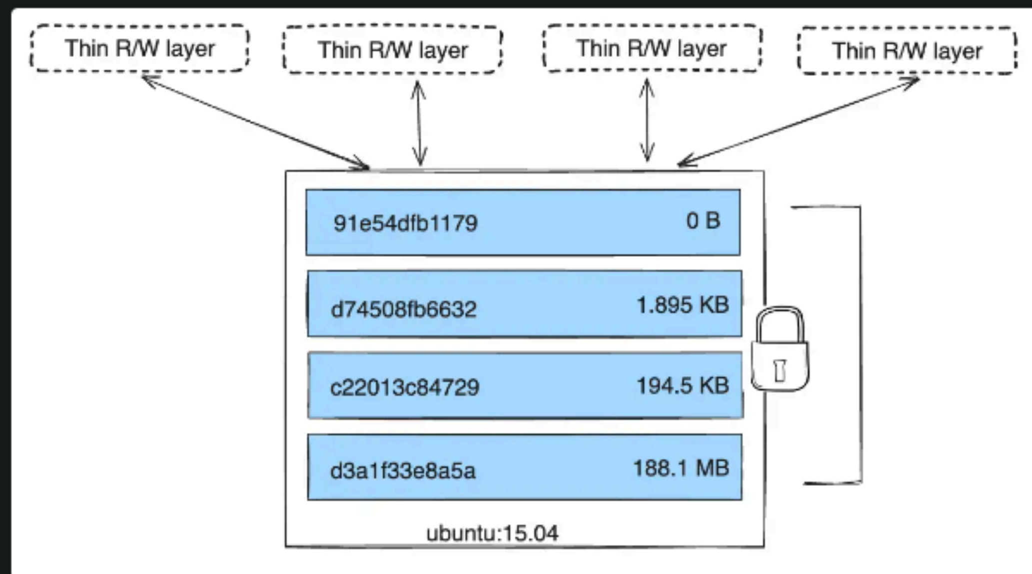
Claim 1	Accused Instrumentalities
	Docker images contain executable application source code as well as all the tools, libraries, and dependencies that the application code needs to run as a container. When you run the Docker image, it becomes one instance (or multiple instances) of the container. It's possible to build a Docker image from scratch, but most developers pull them down from common repositories. Multiple Docker images can be created from a single base image, and they'll share the commonalities of their stack. https://www.ibm.com/topics/docker

Claim 1	Accused Instrumentalities
	Because each container has its own writable container layer, and all changes are stored in this container layer, multiple containers can share access to the same underlying image and yet have their own data state. The diagram below shows multiple containers sharing the same Ubuntu 15.04 image.  https://docs.docker.com/storage/storagedriver/

Claim 1	Accused Instrumentalities
	Docker images contain executable application source code as well as all the tools, libraries, and dependencies that the application code needs to run as a container. When you run the Docker image, it becomes one instance (or multiple instances) of the container. https://www.ibm.com/topics/docker Docker is used to create, run and deploy applications in containers. A Docker image contains application code, libraries, tools, dependencies and other files needed to make an application run. When a user runs an image, it can become one or many instances of a container. https://www.techtarget.com/searchitoperations/definition/Docker-image

Claim 1	Accused Instrumentalities
	 https://ibm.github.io/kube101/

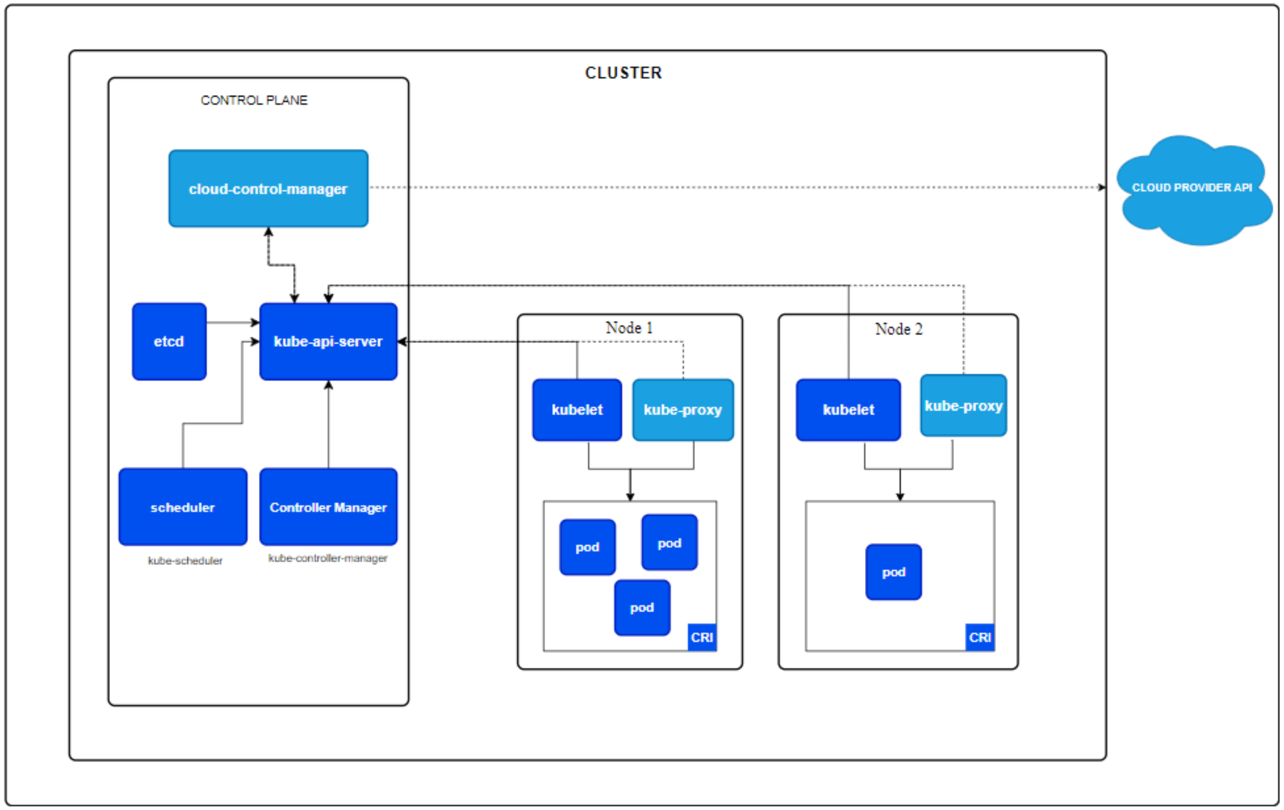
Claim 1	Accused Instrumentalities
[1f] iii) wherein a SLCSE related to a predetermined function is provided to the first of the plurality of software applications for running a first instance of the SLCSE, and wherein a SLCSE for performing a same function is provided to the second of the plurality of software applications for running a second instance of the SLCSE simultaneously.	In each Accused Instrumentality, a SLCSE related to a predetermined function is provided to the first of the plurality of software applications for running a first instance of the SLCSE, and wherein a SLCSE for performing a same function is provided to the second of the plurality of software applications for running a second instance of the SLCSE simultaneously. For example, in Docker or Kubernetes containers, each container operates independently, and a base image includes essential system files, libraries, and dependencies (i.e., SLCSEs) required to run the software application within the container. Based on information and belief, each element, such as system files, libraries, and dependencies (i.e., SLCSE) is associated with an execution of a predetermined function related to the application. When an image is used to create a container in the Accused Instrumentality, an instance of the SLCSE is provided to a software application. Therefore, different instances of the SLCSE are provided to different applications for performing either a same or a different function, simultaneously. *See, e.g.*: Docker is used to create, run and deploy applications in containers. A Docker image contains application code, libraries, tools, dependencies and other files needed to make an application run. When a user runs an image, it can become one or many instances of a container. https://www.techtarget.com/searchitoperations/definition/Docker-image *Docker images* contain executable application source code as well as all the tools, libraries, and dependencies that the application code needs to run as a container. When you run the Docker image, it becomes one instance (or multiple instances) of the container. https://www.ibm.com/topics/docker

Claim 1	Accused Instrumentalities
	Because each container has its own writable container layer, and all changes are stored in this container layer, multiple containers can share access to the same underlying image and yet have their own data state. The diagram below shows multiple containers sharing the same Ubuntu 15.04 image.  https://docs.docker.com/storage/storagedriver/ A container is a runnable instance of an image. You can create, start, stop, move, or delete a container using the Docker API or CLI. You can connect a container to one or more networks, attach storage to it, or even create a new image based on its current state.

Claim 1	Accused Instrumentalities
	https://docs.docker.com/get-started/overview/

Claim 2

Claim 2	Accused Instrumentalities
2. A computing system as defined in claim 1, wherein in operation, multiple instances of an SLCSE stored in the shared library run simultaneously within the operating system.	Each Accused Instrumentality comprises or constitutes a computing system as defined in claim 1, wherein in operation, multiple instances of an SLCSE stored in the shared library run simultaneously within the operating system. For example, an individual host/node runs multiple containers and/or pods simultaneously, each of which has an instance of an SLCSE. *See, e.g.*:

Claim 2	Accused Instrumentalities
	 Kubernetes cluster architecture https://kubernetes.io/docs/concepts/architecture/

Claim 2	Accused Instrumentalities
	Containers Each container that you run is repeatable; the standardization from having dependencies included means that you get the same behavior wherever you run it. Containers decouple applications from the underlying host infrastructure. This makes deployment easier in different cloud or OS environments. Each node in a Kubernetes cluster runs the containers that form the Pods assigned to that node. Containers in a Pod are co-located and co-scheduled to run on the same node. https://kubernetes.io/docs/concepts/containers/

Claim 2	Accused Instrumentalities
	Kubernetes Scheduler In Kubernetes, *scheduling* refers to making sure that Pods are matched to Nodes so that Kubelet can run them. **Scheduling overview** A scheduler watches for newly created Pods that have no Node assigned. For every Pod that the scheduler discovers, the scheduler becomes responsible for finding the best Node for that Pod to run on. The scheduler reaches this placement decision taking into account the scheduling principles described below. If you want to understand why Pods are placed onto a particular Node, or if you're planning to implement a custom scheduler yourself, this page will help you learn about scheduling. https://kubernetes.io/docs/concepts/scheduling-eviction/kube-scheduler/

Claim 2	Accused Instrumentalities
	Running containers Docker runs processes in isolated containers. A container is a process which runs on a host. The host may be local or remote. When you execute `docker run`, the container process that runs is isolated in that it has its own file system, its own networking, and its own isolated process tree separate from the host. https://docs.docker.com/engine/reference/run/

Claim 3

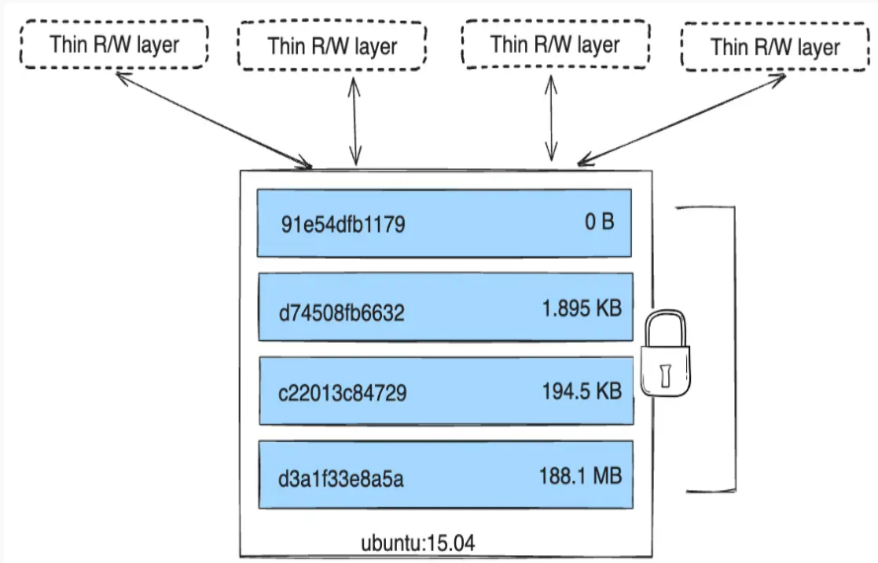
Claim 3	Accused Instrumentalities
3. A computing system according to claim 1 wherein OSCSEs corresponding to and capable of performing the same function as SLCSEs remain in the operating system kernel.	Each Accused Instrumentality comprises or constitutes a computing system according to claim 1 wherein OSCSEs corresponding to and capable of performing the same function as SLCSEs remain in the operating system kernel. For example, both Docker and Kubernetes systems preserve the host kernel substantially unchanged; therefore the OSCSEs corresponding to the SLCSEs remain in the operating system kernel. *See, e.g.*: A Docker image is the basis for every container that you create with IBM Cloud® Kubernetes Service. An image is created from a Dockerfile, which is a file that contains instructions to build the image. A Dockerfile might reference build artifacts in its instructions that are stored separately, such as an app, the app's configuration, and its dependencies. https://cloud.ibm.com/docs/containers?topic=containers-images

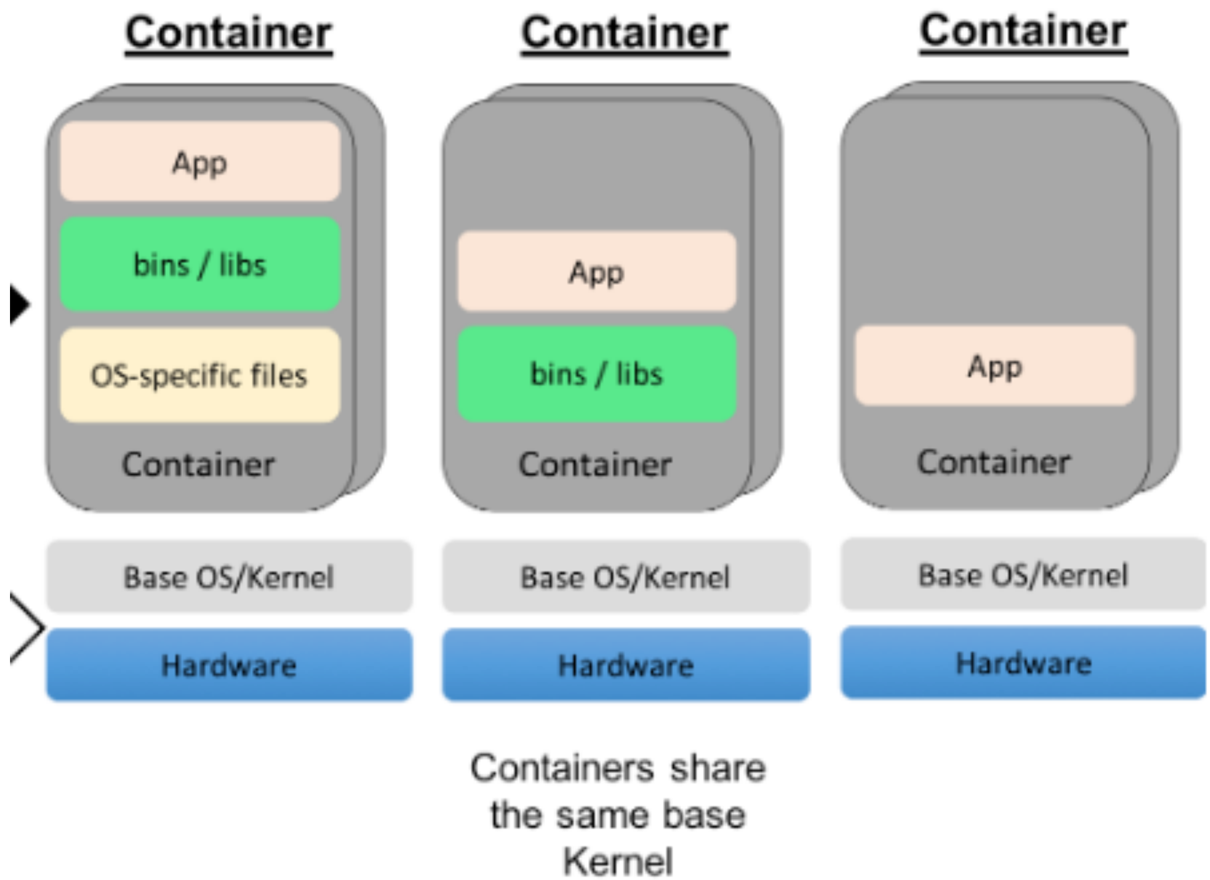
<table>
<tr><th>Claim 3</th><th>Accused Instrumentalities</th></tr>
<tr><td></td><td>
<table>
<tr><th>Docker base image</th><th>Supported versions</th><th>Source of security notices</th></tr>
<tr><td>Alpine</td><td>All stable versions with vendor security support.</td><td>Alpine SecDB database .</td></tr>
<tr><td>Debian</td><td>All stable versions with vendor security support.

CVEs on binary packages that are associated with the Debian source package `linux`, such as `linux-libc-dev`, are not reported. Most of these binary packages are kernel and kernel modules, which are not run in container images.</td><td>Debian Security Bug Tracker .</td></tr>
<tr><td>GoogleContainerTools distroless</td><td>All stable versions with vendor security support.</td><td>GoogleContainerTools distroless</td></tr>
<tr><td>Red Hat® Enterprise Linux® (RHEL)</td><td>RHEL/UBI 7, RHEL/UBI 8, and RHEL/UBI 9</td><td>Red Hat Security Data API .</td></tr>
<tr><td>Ubuntu</td><td>All stable versions with vendor security support.</td><td>Ubuntu CVE Tracker .</td></tr>
</table>

https://cloud.ibm.com/docs/Registry?topic=Registry-va_index&interface=ui
</td></tr>
</table>

Claim 3	Accused Instrumentalities
	## Container images A container image is a ready-to-run software package containing everything needed to run an application: the code and any runtime it requires, application and system libraries, and default values for any essential settings. https://kubernetes.io/docs/concepts/containers/ Container image files are complete, static and executable versions of an application or service and differ from one technology to another. Docker images are made up of multiple layers, which start with a base image that includes all of the dependencies needed to execute code in a container. Each image has a readable/writable layer on top of static unchanging layers. Because each container has its own specific container layer that customizes that specific container, underlying image layers can be saved and reused in multiple containers. An Open Container Initiative (OCI) https://www.techtarget.com/searchitoperations/definition/container-containerization-or-container-based-virtualization

Claim 3	Accused Instrumentalities
	Because each container has its own writable container layer, and all changes are stored in this container layer, multiple containers can share access to the same underlying image and yet have their own data state. The diagram below shows multiple containers sharing the same Ubuntu 15.04 image.  https://docs.docker.com/storage/storagedriver/

Claim 3	Accused Instrumentalities
	 https://ibm.github.io/kube101/

Claim 4

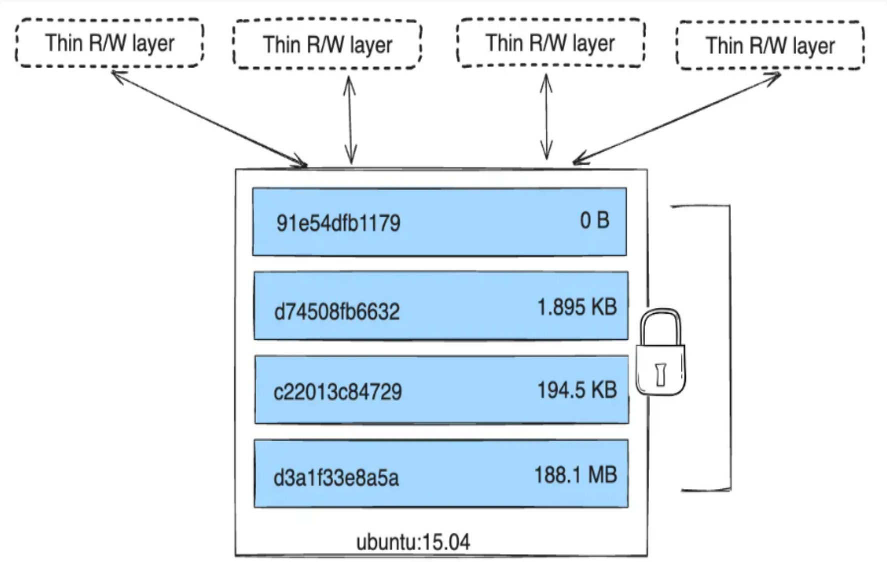
Claim 4	Accused Instrumentalities
4. A computing system according to claim 1 wherein the one or more SLCSEs provided to one of the plurality of software applications having exclusive use thereof, use system calls to access services in the operating system kernel.	Each Accused Instrumentality comprises or constitutes a computing system according to claim 1 wherein the one or more SLCSEs provided to one of the plurality of software applications having exclusive use thereof, use system calls to access services in the operating system kernel. For example, the SLCSEs in a container use system calls to access services in the operating system kernel. For example, the glibc library (or other similar library) in the container uses system calls to interface with the host Linux kernel. In general, system calls can be observed using a tool such as strace. *See, e.g.*: The **GNU C Library**, commonly known as **glibc**, is the GNU Project implementation of the C standard library. It is a wrapper around the system calls of the Linux kernel for application use. Despite its name, it now also directly supports C++ (and, indirectly, other programming languages). It was started in the 1980s by the Free Software Foundation (FSF) for the GNU operating system. https://en.wikipedia.org/wiki/Glibc

	We can now get the process id directly from the cgroup. It will be located in the `cgroup.procs` file.
	`### Terminal 2 - Worker Node ###`
	
	`# Get the process id`
	`$ cat cri-containerd-ceeeef06afe89c8223d33b11e8d9e0b207118ac4dac3af826687668ee1ee`
	`16254`
	
	`# Validate what is running under the process`
	`$ ps aux | grep 16254`
	`azureus+    16254 0.0  0.1 713972 10476 ?        Ssl  15:04   0:00 ./faultyapp`
	`azureus+   94806  0.0  0.0   7004  2168 pts/0    S+   16:22   0:00 grep --color=a`
	
	Got it! With that, we can try to find out what is going out inside the app. Lets try to run `strace` to get some more insight.
	`### Terminal 2 - Worker Node ###`
	
	`$ sudo strace -p 16254 -f`
	`...`
	`# The app is trying to read a file port.txt`
	`[pid 16269] openat(AT_FDCWD, "port.txt", O_RDONLY|O_CLOEXEC <unfinished ...>`
	`[pid 16254] epoll_pwait(5,  <unfinished ...>`
	`# The file does not exist`
	`[pid 16269] <... openat resumed>)       = -1 ENOENT (No such file or directory)`
	`[pid 16254] <... epoll_pwait resumed>[], 128, 0, NULL, 0) = 0`
	`[pid 16269] write(1, "Something went wrong...\\n", 24 <unfinished ...>`
	
	After filtering the output, we can see the application is trying to read a text file called `port.txt`, and a few lines later, there is a message stating `ENOENT (No such file or directory)`. Let's create that file.
	https://www.berops.com/blog/a-different-method-to-debug-kubernetes-pods

Claim 18

Claim 18	Accused Instrumentalities
18. A computer system as defined in claim 2 wherein SLCSEs are not copies of OSCSEs.	Each Accused Instrumentality comprises or constitutes a computer system as defined in claim 2 wherein SLCSEs are not copies of OSCSEs. For example, in a typical case the SLCSEs come from a Linux distribution independent of the host operating system, and thus are not identical to the OSCSEs. For another example, the SLCSEs are provided to the computer system through a separate process than the process by which the OSCSEs are provided to the computer system, and thus are not copied from the OSCSEs. *See, e.g.*: Containers are executable units of software in which application code is packaged along with its libraries and dependencies, in common ways so that the code can be run anywhere—whether it be on desktop, traditional IT or the cloud. To do this, containers take advantage of a form of operating system (OS) virtualization in which features of the OS kernel (e.g. Linux namespaces and cgroups, Windows silos and job objects) can be leveraged to isolate processes and control the amount of CPU, memory and disk that those processes can access. Containers are small, fast and portable because unlike a virtual machine, containers do not need to include a guest OS in every instance and can instead simply leverage the features and resources of the host OS. https://www.ibm.com/topics/containers

Claim 18	Accused Instrumentalities
	Containers use a form of operating system (OS) virtualization. Put simply, they leverage features of the host operating system to isolate processes and control the processes' access to CPUs, memory and desk space. https://www.ibm.com/blog/containers-vs-vms/ Container images A container image is a ready-to-run software package containing everything needed to run an application: the code and any runtime it requires, application and system libraries, and default values for any essential settings. https://kubernetes.io/docs/concepts/containers/ Docker is used to create, run and deploy applications in containers. A Docker image contains application code, libraries, tools, dependencies and other files needed to make an application run. When a user runs an image, it can become one or many instances of a container. ttps://www.techtarget.com/searchitoperations/definition/Docker-image

Claim 18	Accused Instrumentalities
	Because each container has its own writable container layer, and all changes are stored in this container layer, multiple containers can share access to the same underlying image and yet have their own data state. The diagram below shows multiple containers sharing the same Ubuntu 15.04 image.  https://docs.docker.com/storage/storagedriver/